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JOINT HIGHWAY RESEARCH PROJECT

JHRP-76-12

DESIGN AND CONSTRUCTION OF SEVERAL MAINTENANCE TECHNIQUES FOR CONTINOUSLY REINFORCED CONCRETE PAVEMENTS

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PURDUE UNIVERSITY
INDIANA STATE HIGHWAY COMMISSION

Interim Report

DESIGN AND CONSTRUCTION OF SEVERAL MAINTENANCE TECHNIQUES FOR CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS

TO: J. F. McLaughlin, Director
Joint Highway Research Project

March 16, 1976

Project: C-36-52K

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

File: 6-20-11

The attached Interim Report is submitted on the JHRP Research Study entitled "Design and Construction of Several Maintenance Techniques for Continuously Reinforced Concrete Pavements". The report has been authored by Mr. Robert H. Florence, Graduate Research Assistant, on our staff under the direction of Professor Eldon J. Yoder.

The report includes a description of the construction phase of the maintenance study conducted on I-65 south of Indianapolis. This research project resulted from discussions between personnel of the Joint Highway Research Project staff, Indiana State Highway Commission and Federal Highway Administration.

This is a cooperative venture in which the Indiana State Highway Commission as well as the Federal Highway Administration took part in the planning of the research. The construction plans were prepared by the Indiana State Highway Commission under the supervision of Mr. S. R. Yoder. Construction was carried out under the control of Construction Division Personnel in the Seymour District of the Indiana State Highway Commission. The construction was carried out during the fall months of 1975.

Mr. Florence was at the construction site throughout the duration of construction. Professor Yoder was present at the time of several of the critical stages of construction. Samples of subbase and subgrade were obtained and have been stored in the Pavement Design Laboratory of the Joint Highway Research Project. These samples will be tested at a later date.

In addition to the above, acknowledgment is made of the work carried out by Professor D. G. Shurig and personnel from the Research and Training Center relative to deflection measurements and condition surveys prior to construction.

The report is submitted to cover the construction aspects of the research. Additional reports will be submitted from time to time as future condition surveys are made throughout the next several years.

Respectfully submitted,

Harold L. Michael

Harold L. Michael
Associate Director

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16. Abstract

A considerable amount of CRC pavements in Indiana have shown some distress. Past research by Faiz and Yoder have delved into the causes of this distress. Nevertheless, methods to maintain the existing CRC pavements are needed.

This research deals with the design and construction of several maintenance techniques for CRC pavements. A section of pavement on I-65 was stratified into "similar" sections of pavement using deflection, cracking, and breakups as the selection criteria. Various types of maintenance were applied to these sections in the summer and early fall of 1975.

Observations of the construction process were made and detailed descriptions were presented. Preliminary comparisons were made of the effects of the construction along with the comparative costs of each. Specific conclusions cannot be made at this time as to the best type of maintenance to be used. These final conclusions must await a further evaluation period to determine the long term effects of the maintenance. This evaluation will be presented in later reports.

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Interim Report

DESIGN AND CONSTRUCTION OF SEVERAL MAINTENANCE TECHNIQUES FOR CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS

by

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Project No.: C-36-52K

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Prepared as Part of an Investigation

Conducted by

Joint Highway Research Project
Engineering Experiment Station
Purdue University

in cooperation with the

U.S. Department of Transportation
Federal Highway Administration

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

Purdue University
West Lafayette, Indiana
March 16, 1976

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The study was conducted under the guidance of Professor E. J. Yoder. The author's deepest appreciation goes to him for his help and personal involvement in all phases of this research. Throughout the period of this research and the previous years of the author's association with Professor Yoder, he has been a source of encouragement and inspiration. The author considers him a close friend and an outstanding person.

The generous help in funds, equipment, and advice of the FHWA and ISHC has been invaluable to the success of this project. In particular, the assistance rendered by Mr. Stan Yoder is duly acknowledged. Special thanks also goes to Hugh Hunt of the ISHC and Jim Jetts of Tri-State Construction for their full cooperation during the construction phase of this project.

Professor D. G. Shurig of Purdue, Keith Korban of the ISHC, and the ISHC Research and Training Center were all instrumental in the field surveys, and their help is greatly appreciated.

The author is also grateful to Professors Gilbert T. Satterly and Kumares C. Sinha for their review of the manuscript. The moral support of the author's colleagues is gratefully acknowledged.

Appreciation is due to Mrs. Marian Sipes for typing the final manuscript, and the many draftsmen involved in the drafting of the tables and figures in this report.

My most sincere love and thanks goes to my wife, Joan, for her encouragement and support. She went through a great amount of hardship while I spent many nights in Greenwood, Indiana observing construction.

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ABSTRACT

Florence, Robert H., Jr. MSCE, Purdue University, May 1976. Design and Construction of Several Maintenance Techniques for Continuously Reinforced Concrete Pavements. Major Professor: Eldon J. Yoder.

A substantial amount of continuously reinforced concrete pavement has been constructed in recent years in Indiana. A considerable amount of these pavements have shown some distress. Past research by Faiz and Yoder have delved into the causes of this distress. Nevertheless, methods to effectively maintain the existing CRC pavements were needed.

This research deals with the design and construction of several maintenance techniques that will effectively maintain the existing CRC pavements that have shown distress. A section of continuously reinforced concrete pavement on I-65 was stratified into "similar" sections of pavement using deflection, cracking, and breakups as the selection criteria. Various types of maintenance were applied to these similar sections and were constructed in the summer and early fall of 1975.

Observations of the construction process were made and detailed descriptions were presented. Preliminary comparisons were made of the effects of the construction along with the comparative costs of the various types of construction. Specific conclusions cannot be made at this time as to the best type of maintenance to be used. These final conclusions must await a further evaluation period to determine the long term effects of the maintenance. This evaluation will be presented in later reports.

INTRODUCTION

The Indiana State Highway Commission has constructed about 695.5 two lane miles of continuously reinforced concrete pavement during the past 10 years. By and large, these have been constructed on the Interstate System.

A considerable mileage of these pavements have shown some distress (about 1/3 of the mileage as of the summer of 1972). The Joint Highway Research Project was asked to conduct research into the possible causes of the distress. A series of reports covering the findings have been prepared and presented to the JHRP Advisory Board (see References 16 to 24).

This research deals with the construction of several maintenance sections to evaluate the most cost effective method to repair the CRC pavements which have shown distress in Indiana. Techniques presented in the research are based upon a stratification of a section of road into "similar" sections of pavement using deflection, cracking, and break-ups of the pavement as the selection criteria.

HISTORY OF RESEARCH ON CRCP IN INDIANA

Primary emphasis was placed on construction of CRCP from the years 1967-1971. By the spring of 1972 it became apparent that severe distress was occurring on some of the pavements.

Purdue University was first contacted in July of 1972 regarding the problem at which time plans were made for a long range research project. Several reports have been prepared by Faiz and Yoder (16-18 and 20-24).* Specific recommendations were made relative to design changes that might be adopted to improve the performance of this type of pavement.

This research followed a sequential process which has culminated in this maintenance study. The list given below is a very brief summary of the approach that was taken.

1. Detailed study of performance on I-65. This was conducted during the summer months of 1972.
2. Statewide performance survey of all CRC pavements in Indiana. This part of the study was conducted in late fall of 1972.
3. Detailed study of selected pavements including field measurements. This portion of the study was conducted in early summer 1973.
4. Laboratory evaluation of materials obtained in step 3 above. This phase of the study was completed in January 1975.

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*Numbers in parentheses refer to references at the end of this report.

5. Analysis of factors influencing performance. This phase of the study was completed in early summer 1975.

Significant Factors Influencing Performance

After several months of research on CRC pavements in Indiana, it became apparent that several factors were showing up as being statistically significant with respect to design and performance of this type of pavements in Indiana. These factors have been discussed in detail in several reports (20-23). The factors influencing the performance of CRCP included (1) subbase type, (2) type of steel fabrication, (3) an interaction of steel placement methods and construction, and (4) traffic.

The following paragraphs discuss some of the features which have been found to influence the performance of these pavements. These factors are not necessarily in the order of importance since it is believed that there is no single factor which has influenced performance. Rather, it is a combination of factors that, when combined, have set up a series of circumstances which have caused failures to occur.

Subbase Type

The early surveys showed that pumping was occurring on the pavements which showed the greatest amount of distress. This factor was first reported to the Joint Highway Research Project Advisory Board on September 7, 1972 (16). It was pointed out that most of the pumping was occurring on the gravel subbases and that the crushed stone and slag subbases were apparently showing good performance.

There was a marked increase in defects per mile on I-65 from the summer of 1972 to the fall of 1973 (23). This was true of the gravel subbase sections and the single bituminous stabilized subbase section just north of Lebanon.

The section with the crushed stone subbase (north of US 24) has shown excellent performance since its construction. The amount of fines in the subbases was always somewhat higher at the failed location as compared to the good locations, but the differences were small.

Properties of Granular Subbases

In view of the earlier analyses that brought to light significant differences among the properties and behavior of crushed stone, slag, and gravel subbases, the subbase data was first segregated by subbase type. The properties of the gravel subbases were comparatively analyzed relative to poor and adequate pavement condition. Such an analysis could not be done on the other subbase types owing to paucity of data. Finally the variation of important subbase characteristics with subbase type was tabulated.

The CBR data for gravel subbases was analyzed using ANOV. Only ten test sections were used for each condition type. Results derived from this analysis indicated little difference in subbase CBR relative to pavement condition. On the other hand, the CBR values obtained at the core-hole (an average CBR of 44 percent) were significantly larger than those measured at the shoulder (an average CBR of 35 percent). In any case, the CBR values were invariably low.

The grain-size distribution, percent compaction, and permeability of gravel subbases were essentially the same at both the sections with and without failures - as was shown by the results of t-tests on these properties. Even so, the degree of compaction achieved for the gravel subbases was uniformly low (about 93 percent of standard AASHTO on the average).

Comparison of Subbase Types

Table 1 describes the variation of subbase CBR, permeability, and degree of compaction with subbase type. Though no clear differences in the properties of the gravel subbases were evident between sections with failures and sections showing no apparent distress, the gravel subbases were not sufficiently compacted and had relatively low permeability and strength.

The results bring to light important differences among the properties of the different subbase types. Crushed stone subbases were the most permeable while slag subbases had the lowest permeability. The relatively poor water transmission characteristics of the slag subbase was more than balanced by its high strength, as indicated by CBR.

Interaction Between Permeability and Strength

It is worthwhile to note that concrete pavement performance is also a function of the interaction between subbase permeability and strength (CBR). In Figure 1, the estimated field permeability values are plotted against field subbase CBR values measured at the shoulder-slab interface. These values pertain to 46 test locations of the detailed field study. Test data for crushed stone and slag subbases are shown with separate indicators. In addition, values obtained at failed-test locations are differentiated from the values at good-test locations. The data were grouped in nine categories corresponding to three levels each of subbase CBR and permeability. For low subbase strength (CBR < 40 percent), mainly gravel subbases, the percentage of failed test locations decreased from 53 percent in the low permeability group (k < 100 ft/day) to 25 percent in the high permeability group (k > 1000 ft/day). For medium subbase strength (40 percent < CBR < 80 percent), no failures were observed where permeability was

TABLE I. EFFECT OF SUBBASE TYPE ON PAVEMENT CONDITION *

TYPE OF SUBBASE	CONDITION OF TEST SECTIONS	NO. OF TEST SECTIONS	SUBBASE CBR		PERMEABILITY K	COMPACTION
			SHOULDER	CORE		
Gravel	With Failures	13	33.5%	38.0%	978.9 ft/day**	91.5%**
	Without Failures	10	35.9	45.2	702.6***	93.2***
Slag	With Failures	1	95.0	100.0	30.0	117.2
	Without Failures	3	81.0	96.6	142.9	100.6
Crushed Stone	With Failures	1	32.0	41.0	1369.7	89.9
	Without Failures	1	90.0	59.0	2497.1	85.3

* FROM FAIZ (REF. NO. 23).

** AVERAGE OF VALUES FROM NINE TEST SECTIONS.

*** AVERAGE OF VALUES FROM TEN TEST SECTIONS.

NOTE: DATA FROM STRUCTURALLY SOUND TEST LOCATIONS.

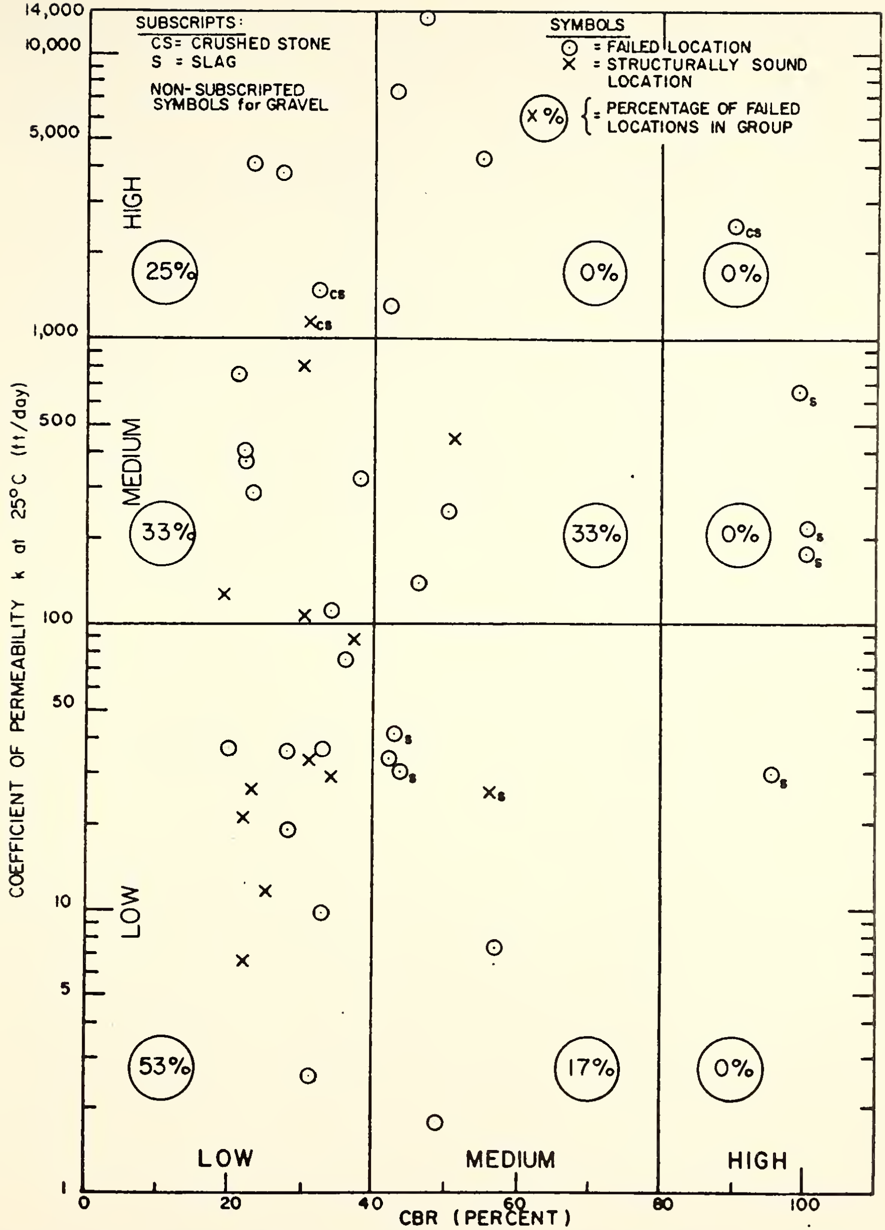


FIG. 1. EFFECT OF SUBBASE STRENGTH AND PERMEABILITY ON CRCP PERFORMANCE (FROM FAIZ, REF. 23).

greater than 1000 ft/day. Where subbase strength (CBR > 80 percent) was high (applies only to slag and crushed stone subbases) no failures were indicated irrespective of permeability.

It has been suggested in reports submitted to the Indiana State Highway Commission from the outset that pumping is a major contributor to distress to the pavements and that the gravel subbases have shown the poorest performance. The cold-mix bituminous stabilized bases have shown fair to good performance. Recommendations made to the Indiana State Highway Commission on November 10, 1972 (16) included discontinuance of use of gravel subbases and it was suggested that crushed stone subbases (drained) or stabilized subbases should be used. Data obtained suggest slag subbases are showing good performance.

Percent of Steel

Six tenths (0.6) percent steel has been adopted by most states as a standard value for use in CRCP.

The temperature drop used by the Indiana State Highway Commission for the design of these pavements is 100^{o}F. However in the central and northern portions of Indiana temperature drops from extreme highs during the construction season in mid-summer to winters may go as high as 125^{o}F or greater (23). According to computations of the effect of total temperature drop on required percentages of steel using split-tensile strength values from pavement cores, a temperature drop of 125^{o}F requires more than 0.6% steel. This suggests that 0.6 percent steel is too low for Indiana conditions.

Steel Placement

The survey data have shown that a major contributor to failures occurring on continuously reinforced concrete pavements in Indiana can be associated with use of pre-set steel set on chairs. This was reported as early as September 1972 (16).

Recommendations for discontinuance of use of pre-set steel were also made orally to the state in 1972 (16).

Thickness

This particular factor no doubt needs additional research before definite conclusions can be made. Nevertheless, the Indiana design has followed the standard recommendations of using a reduction factor of about 0.75. Opinions expressed by various individuals across the United States have suggested that reduction in thickness should not be permitted.

In spite of the lack of substantiating data, it is probable that the thickness design used on CRC pavements in Indiana is at best marginal.

Construction and Other Factors

The above discussion pertains primarily to factors which can be assumed to be in the "design" category. The total research study, however, has dealt with other factors which might affect performance of CRC pavements. Reference is made in particular to the report by Faiz and Yoder (22) which dealt with physical properties determined in the field on selected pavements during the summer of 1973.

Among the more important significant factors was the effect of bulk density of the concrete on performance of the pavements. Concrete at failed locations had lower bulk densities than at good locations. Likewise, the dynamic modulus of elasticity was found to be a contributing factor. On the other hand, the split-tensile strength values were not found to be significantly different between failed and structurally sound locations.

The results of the study showed that there was little difference between the properties above and below the steel reinforcement.

The results of the field survey indicated that no significant difference existed in the mean crack interval as indicated between good and failed locations. It was shown that most of the failed sections were associated with intersecting cracks.

Summary of Past Findings

The comments offered below pertain to the past research on factors which have influenced performance of continuously reinforced concrete pavements in Indiana.

The comparison of test sections with failures as opposed to sections without failures in the detailed field evaluation (23), relative to material properties and performance characteristics evaluated at structurally sound test locations, resulted in a number of significant results. Similarly the evaluation of section-wide pavement characteristics also established some significant trends. These findings bring to light inherent deficiencies in the pavement structure that eventually lead to distress.

The following is a summary of the significant results (23):

1. Subgrade Properties: The only significant result in the analysis of subgrade properties showed that subgrade soils at sections without failures were relatively more coarse grained and sandy than sections where failures had occurred.
2. Subbase Properties: This analysis clarified the reasons for the better performance of certain subbase types. Crushed stone subbase, at the section without failures was found to possess a high strength (CBR of 90 percent) and excellent internal drainage (over 2000 ft/day). The failure

on another section with a crushed stone subbase was a function of poor stability (ver low CBR), resulting from inadequate compaction. The good condition of pavements on slag subbases was due to the very high stability (CBR of over 100 percent) of this subbase. At structurally sound locations, gravel subbases were found to have a moderately high permeability but showed poor stability characteristics, probably a function of insufficient compaction.

3. Concrete Properties: It was shown that sections showing no failures were paved with a higher slump concrete. The results of data analysis further indicated that the modulus of elasticity of concrete had a significant bearing on pavement condition. Concrete cores obtained from sections without any distress were tested to have an average dynamic modulus of elasticity of 6.15 million psi whereas cores, obtained from good locations on sections that had failures, had an average dynamic modulus of 4.97 million psi.

4. Dynamic Pavement Deflection: Dynamic pavement deflections were shown to be a good indicator of pavement condition if used judiciously. Once the continuous slab breaks up into discrete segments, the usefulness of deflections measurements is impaired. As expected at good test locations, no difference in dynamic deflections was observed between sections with failures and sections without failures.

   An evaluation of section-wide deflection measurements taken at 6.0 ft from the pavement edge showed that for 9-in. CRCP, dynamic deflections less than 0.5 milli-in., as measured by Dynaflect, are indicators of good pavement condition. Deflections in the range of 0.6-0.9 milli-in. spell a potential distress condition while values above 1.0 milli-in. are indicators of severe distress with a high probability of pavement breakups.

5. Crack Width: It was noted that crack widths observed at test sections with failures were significantly wider than those measured at good test sections, even though crack widths at only structurally intact locations were measured. The average crack width at good sections was 0.0087 in.
6. Crack Spacing: No difference in either the mean crack spacing or the variance of crack intervals was observed between sections falling in the two categories. The variance of crack spacing at failed test locations was significantly higher than the variance at good locations. Frequent incidence of bifurcated cracks, as well as closely spaced cracks which may intersect at a later date, was observed to be associated with failures. Also, high incidence of very closely spaced cracks is indicative of incipient failure.

PURPOSE OF THE STUDY

Webster describes maintenance as the act of keeping in the existing state or preserving, from failure or decline. He defines rehabilitation as the process of restoring to a former capacity. While rehabilitation may be a more accurate term for the subject of this research, since the processes herein described are rarely used unless some degree of failure has already occurred, the term maintenance shall be used throughout this report.

The primary purpose of highways has long been acknowledged to be the provision of a safe, comfortable, convenient, and economical method of transporting goods and people. If any of these features no longer exist, the highway is inadequate and requires either maintenance or a complete rebuilding depending on the degree of inadequacy.

It was the purpose of this research to design and construct several different types of maintenance for sections of continuously reinforced concrete pavement. Deflection, the amount of cracking, and the amount of breakups were used as significant indicators of performance and were the basis of selection of the experimental sections.

Faiz (23) has suggested that deflections, as measured by the Dynaflect, greater than 0.9 mils are indicative of poor pavement condition. Hence, it follows that the reduction of deflections is one method of reducing potential failure of the pavement. Poor drainage, often caused by the previously mentioned factors was considered to be a major contributor to the high deflection. A third factor was found to be the use of bar mats and pre-set steel on chairs.

A section of I-65 south of Indianapolis, (Contract No. R-8001), was chosen for this project. This section extends southward from the Greenwood exit of I-65 to the Whiteland exit and the test pavements included both the Northbound and Southbound lanes. This resulted in approximately 4.6 miles in each direction or a total of about 9.2 miles of test pavement.

This section was selected for study since it contains all of the significant features identified as major contributors to performance of CRCP. It has a gravel sub-base and bar mats and chairs were used. These are three important criteria discussed earlier in this report that indicate potential failure. The grade is relatively flat, soils are fine grained glacial till, and drainage is generally poor. This pavement has shown, as predicted, very poor performance.

PROCEDURE FOR SELECTION OF TEST SECTIONS

Indicators of Pavement Condition

Crack widths, deflection, and breakups were the criteria used for indicators of poor pavement condition.

Randomly spaced transverse cracking of a CRCP pavement does not necessarily indicate potential failure. However, when the cracking is closely spaced (< 30"), or when cracks intersect with other cracks, the data has demonstrated that poor performance may result.

Deflection of the pavement has long been acknowledged to be a useful measurement to evaluate the overall condition and structural capacity of highway pavements. Previous studies (16-24) have suggested 0.9 mils as measured by the Dynaflect may indicate poor performance. Although single widely spaced deflection measurements are easy to make and give some indication of the overall pavement condition, more closely spaced regular measurements show the changes in the pavement capacity and give the engineer a deflection profile of the pavement. For example, a series of high deflections are definite indicators of lack of support and probable failure of a section of pavement, whereas, the potential failure area might be overlooked in randomly spaced deflection measurements.

Initial Tests

With the above information in mind, deflection measurements and a condition survey of the pavement were made in the fall of 1974. Deflection readings were taken with the Dynaflect (Figure 2) at 25' intervals over the study area.

FIGURE 2. PAVEMENT DEFLECTIONS WERE MEASURED WITH THE DYNAFLECT

The condition survey was made noting the size and location of breakups, and the location and lineal feet of closely spaced parallel cracks, intersecting cracks, and combination cracks. Figure 3 shows the criteria used for determining the lineal feet of cracking. Lineal feet of cracking (L on Figure 3) was the longitudinal distance a specified type of crack was observed.

Method of Selecting Study Sections

Reference is made at this time to the flow chart, Figure 4. Using the data derived from the above tests, the following factors were calculated: (1) lineal feet of closely spaced parallel cracking (< 30") plus lineal feet of intersecting cracking plus lineal feet of combination cracking per 100 ft. station, (2) total area of breakups per 100 ft. station, and (3) maximum deflection per 100' section. This procedure permitted the changing the readings from the highly incremental 25' sections to a more workable 100' section.

These 100' sections were then rated from 1 to 3 with respect to each of the following:

	Amount	Rating
Breakups	0	1
	1 → 30 ft^2/100'	2
	$\geq$ 30 ft^2/100'	3
Cracking	0 → 30 ft/100'	1
	30 → 50 ft/100'	2
	$\geq$ 50 ft/100'	3
Deflection	0 → 0.6 milli-in.	1
	0.6 → 1.0 milli-in.	2
	1.0 milli-in. →	3

The limits of each rating number were determined by counting the number of 100' sections with various values and separating the sections at appropriate break points.

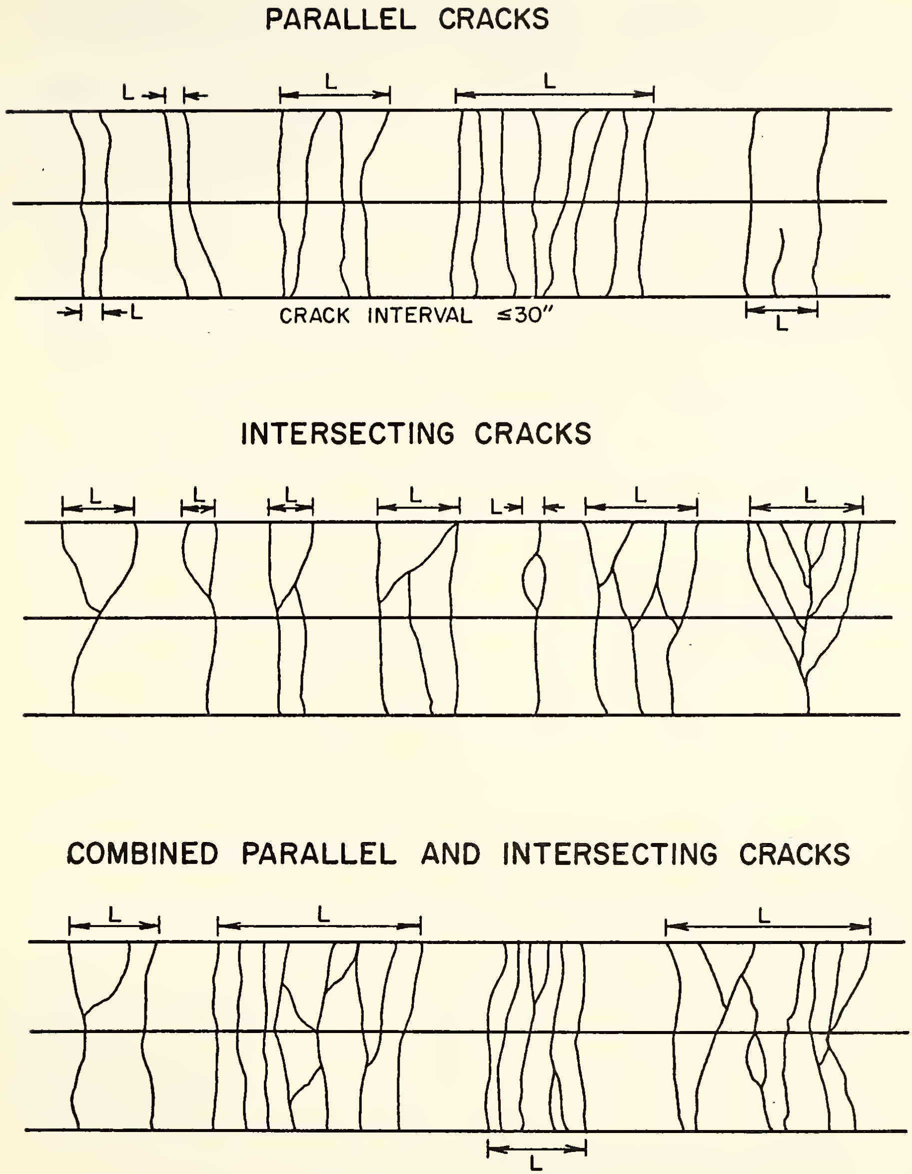


FIGURE 3. TYPICAL CRACK PATTERNS

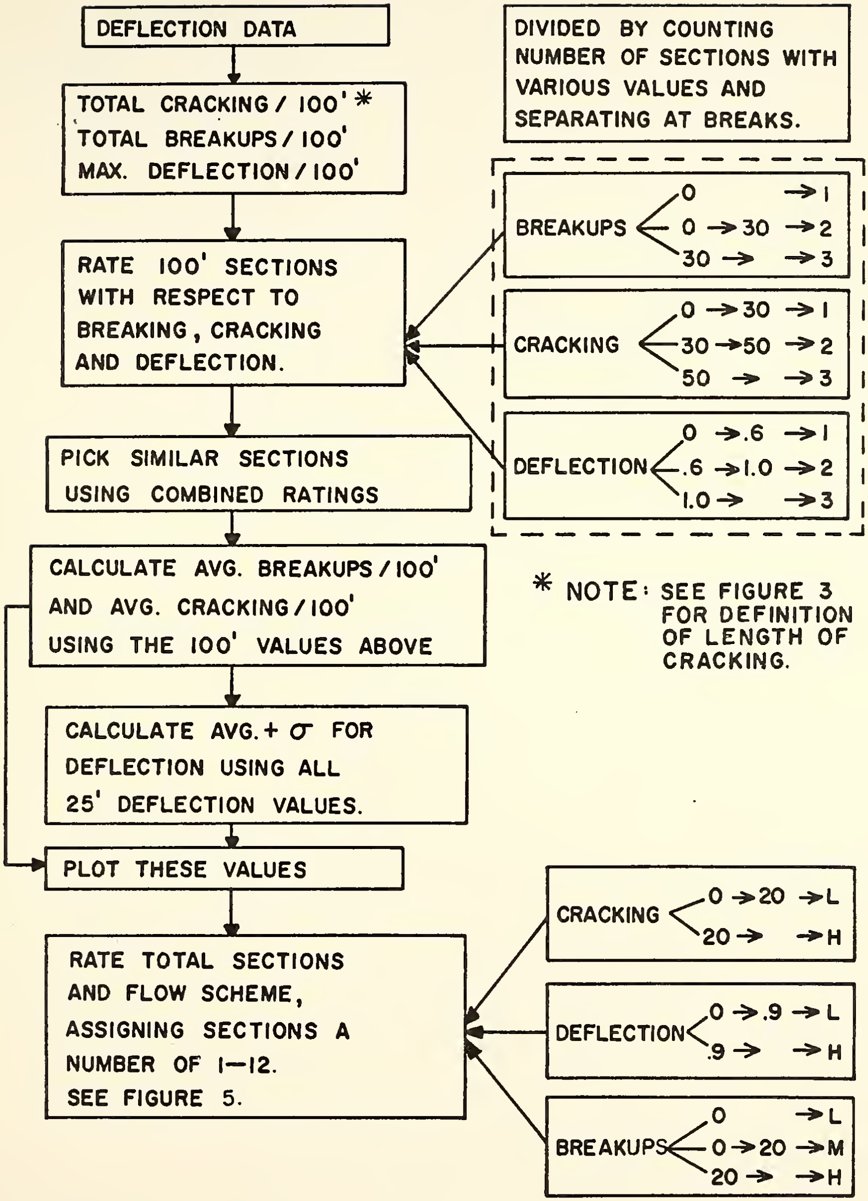


FIGURE 4. FLOW CHART SHOWING PROCEDURE FOR SETTING UP TEST SECTIONS

From these combined ratings, similar sections were chosen. The average breakups per 100 ft. and the average cracking per 100 ft. were then calculated using the 100 foot values previously calculated. The statistic for deflection used was the average plus one standard deviation of the deflections using all the values.

These average values were then divided as follows:

	Amount	Rating
Cracking	< 20 ft/100'	low
	> 20 ft/100'	high
Deflection	<.9 milli-inches	low
	>.9 milli-inches	high
Breakups	0	low
	0 < 20 ft^2/100'	medium
	> 20 ft^2/100'	high

Using these ratings, the sections were then stratified and assigned rating numbers of 1 to 12 as shown in Figure 5.

Selection of Maintenance Methods

Table 2 shows the types of maintenance that were considered to be appropriate for the given rating numbers. This list was used as a "shopping list" from which maintenance types could be chosen. An attempt was made to apply as many types of appropriate maintenance as possible to the various ratings, but all the types of maintenance were not used in some cases. The list was compiled during a conference of personnel from Purdue University, the Indiana State Highway Commission and the Federal Highway Administration.

Layout of Study Sections

The layout of study sections of a given maintenance type was governed by four criteria:

1. It was desirable to make a section of one type of maintenance as long as possible;

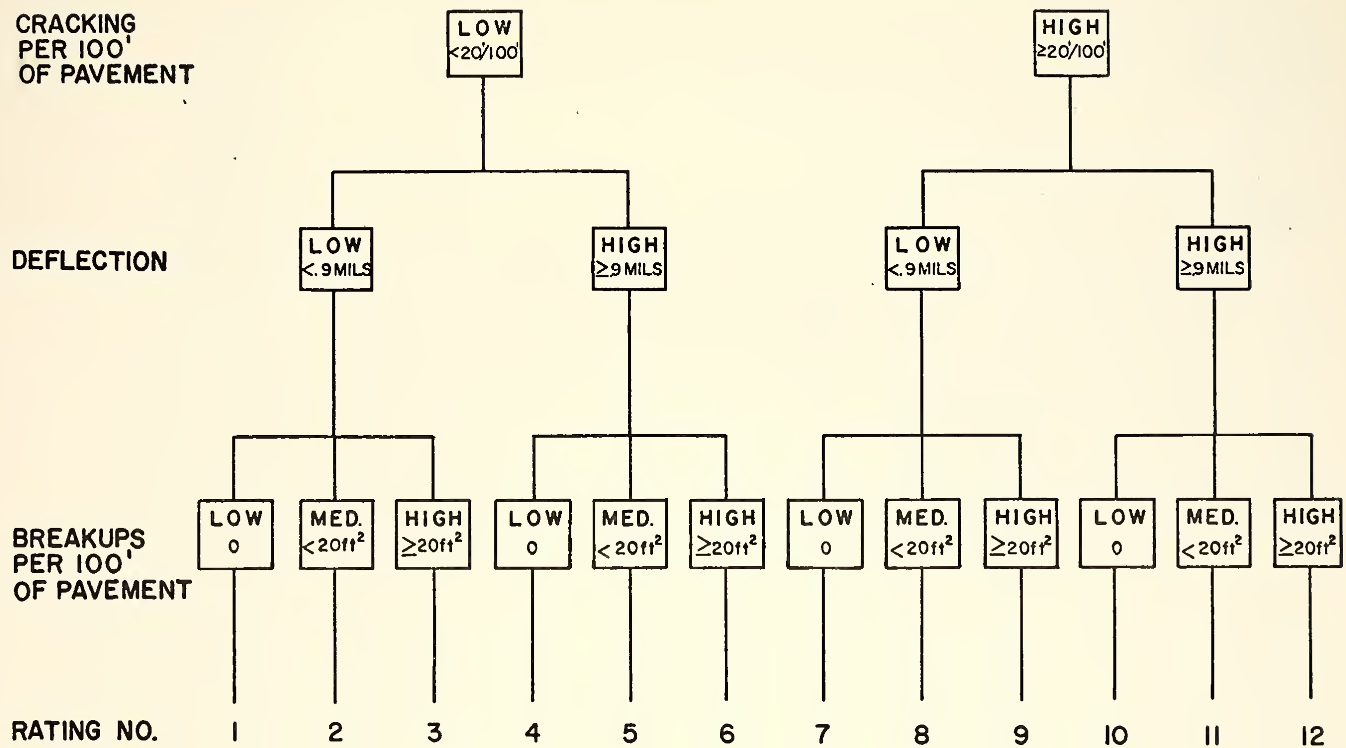


FIGURE 5. RATING OF TEST SECTIONS

TABLE 2. POSSIBLE MAINTENANCE*

Rating No.	Type of Maintenance
1	No Maintenance
2	No Maintenance; Patch
3	No Maintenance; Patch
4	No Maintenance; Underseal & Overlay, Underseal; Overlay; Concrete Shoulders; Drain
5	No Maintenance; Patch, Underseal & Overlay; Patch & Underseal; Patch & Overlay; Patch & Concrete Shoulders; Patch & Drain; Patch, Drain & Concrete Shoulders
6	No Maintenance; Patch, Underseal & Overlay; Patch & Underseal; Patch & Overlay; Patch & Concrete Shoulders; Patch & Drain
7	No Maintenance; Drain; Overlay
8	No Maintenance; Patch & Overlay; Patch & Concrete Shoulders; Patch & Drain; Patch
9	No Maintenance; Patch & Overlay; Patch & Concrete Shoulders; Patch & Drain; Patch
10	No Maintenance; Underseal & Overlay; Concrete Shoulders; Drain
11	No Maintenance; Patch, Underseal & Overlay; Patch & Drain; Patch & Concrete Shoulders; Full Depth Bituminous
12	No Maintenance; Patch, Underseal & Overlay; Patch & Drain; Patch & Concrete Shoulders; Full Depth Bituminous; Patch, Underseal, Overlay, Drain & Concrete Shoulders; Patch, Drain & Concrete Shoulders

*Note that the table presents a "shopping list" of possible maintenance. These were varied to fit construction needs, etc. (see Table 3).

2. Retain at least 1 "control section" for each rating number 1 → 12;
3. Use as many different types of maintenance methods as possible for each rating number;
4. Allocate the maintenance to be used to the rating numbers with the fewest actual sections of that rating first. (Note that this criterion is a means for attaining the first three criteria.)

A tabulation of the sections is shown in Table 3.

Modifications of Layout Due to Spring 1975 Tests

Deflection measurements were taken and a condition survey was made during the Spring of 1975 (after spring thaw) to further evaluate the pavement. This required a few minor changes in the layout of the test sections. The construction plans were prepared by the Indiana State Highway Commission and construction began about the middle of August, 1975. Data shown in Table 3 are the final as-built sections and corresponding stations.

TABLE 3. STATIONS VS MAINTENANCE USED

	Stations	Maintenance Used
SBL	990+00- 995+00	No maintenance
	995+00- 996+00	Patch
	996+00-1001+00	No maintenance
	1001+00-1008+00	Patch
	1008+00-1018+50	Concrete shoulder
	1018+50-1033+05	Concrete shoulder & drain
	1033+05-1036+00	Patch
	1036+00-1050+00	Underseal & overlay
	1050+00-1059+00	Drain
	1059+00-1090+00	Underseal
	1090+00-1141+00	Patch
	1141+00-1171+00	Underseal & overlay
	1171+00-1196+00	Patch
	1196+00-1204+00	Full depth bituminous patch
	1204+00-1209+00	No maintenance
	1212+15-1224+00	Concrete shoulder
	1224+00-1235+00	Patch
NBL	990+00- 994+00	No maintenance
	994+00-1025+00	Patch
	1025+00-1065+00	Drain
	1065+00-1066+00	Concrete shoulder & drain
	1066+00-1072+05	Concrete shoulder
	1072+05-1082+00	Patch
	1082+00-1101+00	Underseal & overlay
	1101+00-1138+05	Overlay wedge
	1138+05-1143+00	Overlay & drain
	1143+00-1148+00	Underseal & overlay
	1148+00-1152+00	Overlay
	1152+00-1161+00	No maintenance
	1161+00-1167+00	Drain
	1167+00-1172+00	Underseal
	1172+00-1176+00	No maintenance
	1176+00-1209+00	Patch
	1212+00-1235+00	Overlay

Note: Concrete patching was done where needed in all areas except no maintenance sections.

MAINTENANCE METHODS USED

During the construction of the maintenance, Purdue personnel were present, serving in an advisory capacity, and working closely with the Indiana State Highway Commission field personnel. The following pages are a summary of the method of construction of each maintenance type along with explanations of the changes that were necessary during the construction and general observations of construction procedures. Each maintenance type is discussed separately with pictures and figures to assist in the explanations.

All breakups on the project were patched regardless of type of maintenance used.

The locations of the various maintenance methods can be seen in Figure 6.

Concrete Shoulders

In recent years, concrete shoulders have been utilized more and more to reduce maintenance problems associated with the shoulder area itself. In addition, concrete shoulders tied to the existing pavement, serve to stiffen the existing pavement and thereby decrease the deflection and consequent pumping and failure of the pavement. Plain concrete shoulders were deemed adequate for this project due to the frequency of load applications on the shoulders.

Construction (Figures 7 to 15)

The concrete shoulders were constructed with contraction joints spaced at 15 foot intervals. The slabs were six inches thick on the outside edge and nine inches thick on

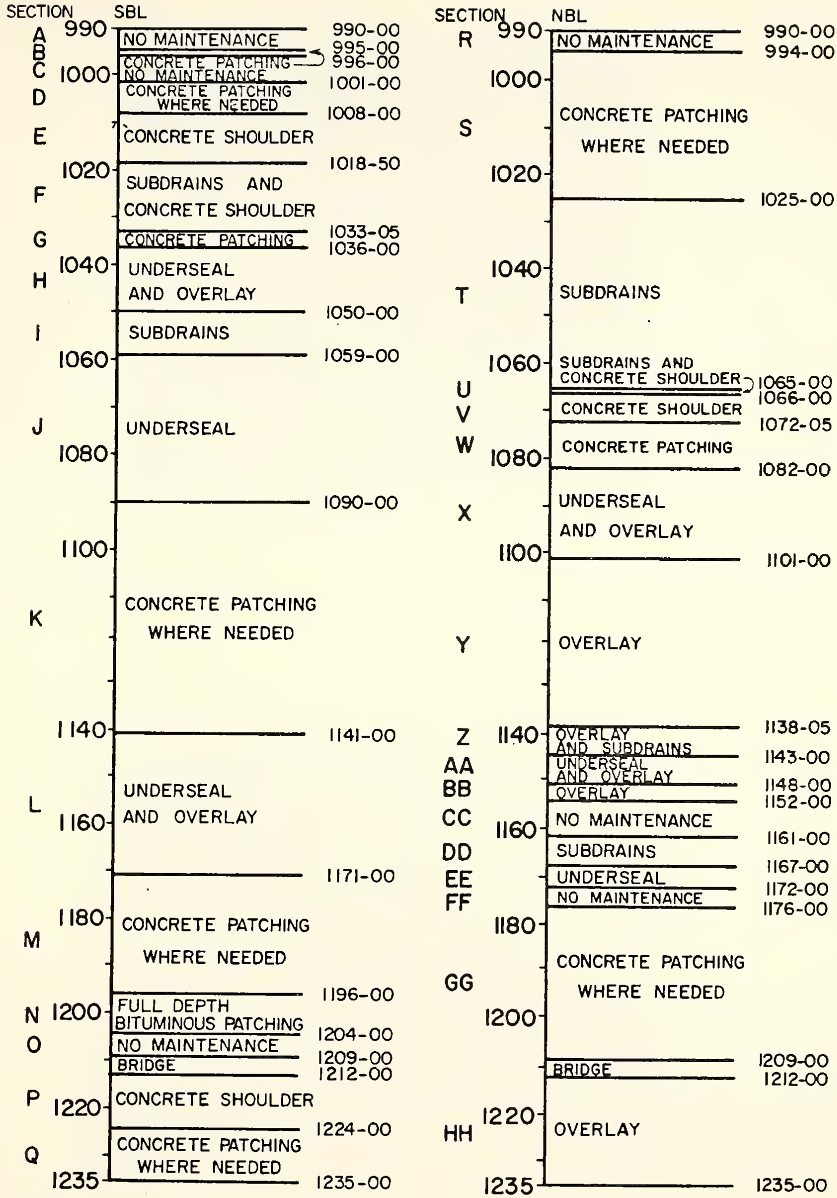


FIGURE 6. AS BUILT MAINTENANCE SECTIONS

NOTE: CONCRETE PATCHING WAS DONE WHERE NEEDED IN ALL AREAS EXCEPT NO MAINTENANCE SECTIONS.

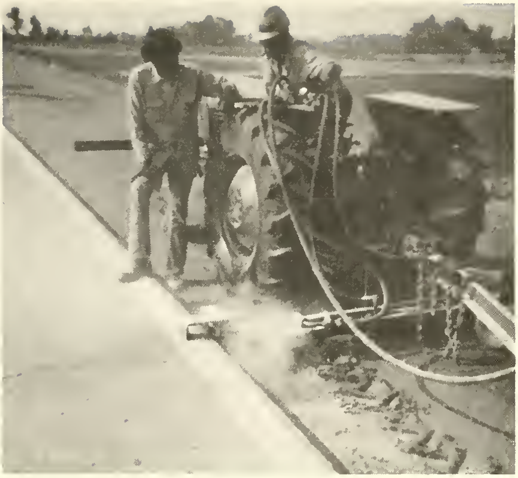


FIGURE 7. DRILLING HOLES FOR TIE BARS IN CONCRETE SHOULDERS

FIGURE 8. TIE BARS IN PLACE PRIOR TO POURING CONCRETE SHOULDER

FIGURE 9. POURING CONCRETE SHOULDER

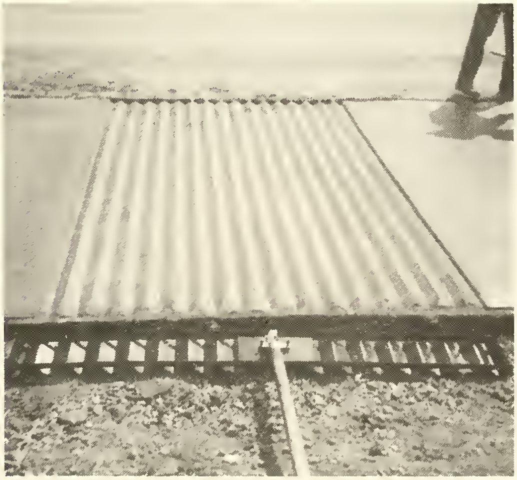


FIGURE 10. FORMING A RUMBLE STRIP IN CONCRETE SHOULDER WITH CORRUGATED METAL PLATE

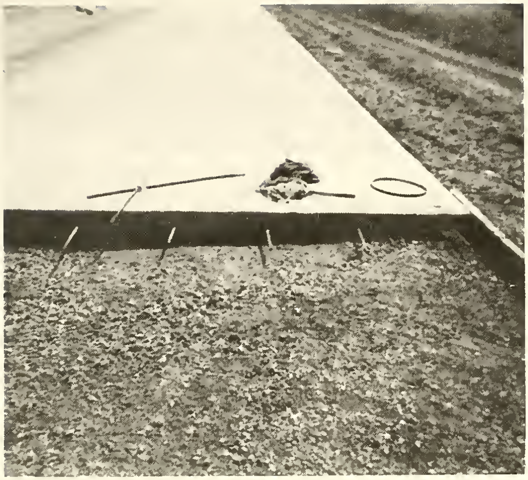


FIGURE 11. CONSTRUCTION JOINT IN CONCRETE SHOULDER

FIGURE 12. COMPLETED CONCRETE SHOULDER

the inside edge. Figure 13 shows the cross-section of the concrete shoulders. They were tied to the existing pavement with 30 inch long No. 4 tie bars.

The tie bars were spaced at three different intervals (12" c-c, 24" c-c, and 30" c-c) at specific locations in the project as shown in Figure 14. The tie bars were omitted 2'-6" on either side of the contraction joints to permit independent movement between the existing CRC pavement and the concrete shoulder. This spacing system required 11 bars/slab at the 12" spacing, 6 bars/slab at the 24" spacing, and 5 bars/slab at the 30" spacing as seen in Figure 15.

After excavation and grading of the existing asphalt shoulder to the pavement depth, holes were drilled into the existing pavement to a depth of 14" with a tractor mounted drill. The tie bars were grouted into the existing pavement with a combination of AASHO M235-721 epoxy and Ferrolith "G" non-shrinking grout. After the tie bars were set and forms installed, the shoulders were poured. A vertical plane was "broken" with a vertical blade on a finishing tool immediately after pouring the concrete. The joints were then cut with a concrete saw after the initial set of the concrete.

Rumble strips were installed every 60 foot along the concrete shoulder. Construction joints were installed at the end of each days pour. They were always located in the middle of a slab and tied with tie bars. After the forms were removed, the joints were sealed with asphalt and sides backfilled with existing aggregate.

Changes During Construction

1. The tie bar spacing from station 1212+15-1224+00 in the South Bound Lane (Section "P") did not conform to the original plans as the contractor did not allow for the 2'-6" space at each end of the slab when drilling the tie

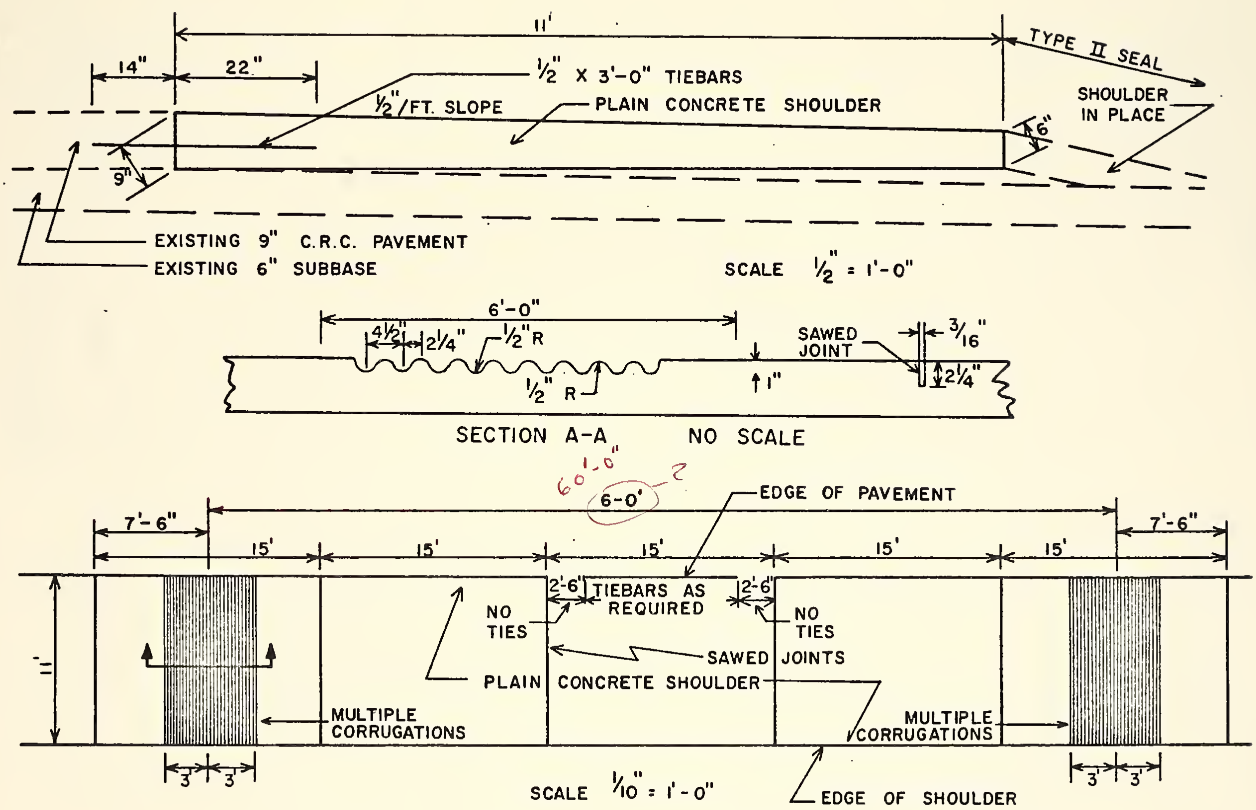


FIGURE 13. PLAIN CONCRETE SHOULDER DETAILS

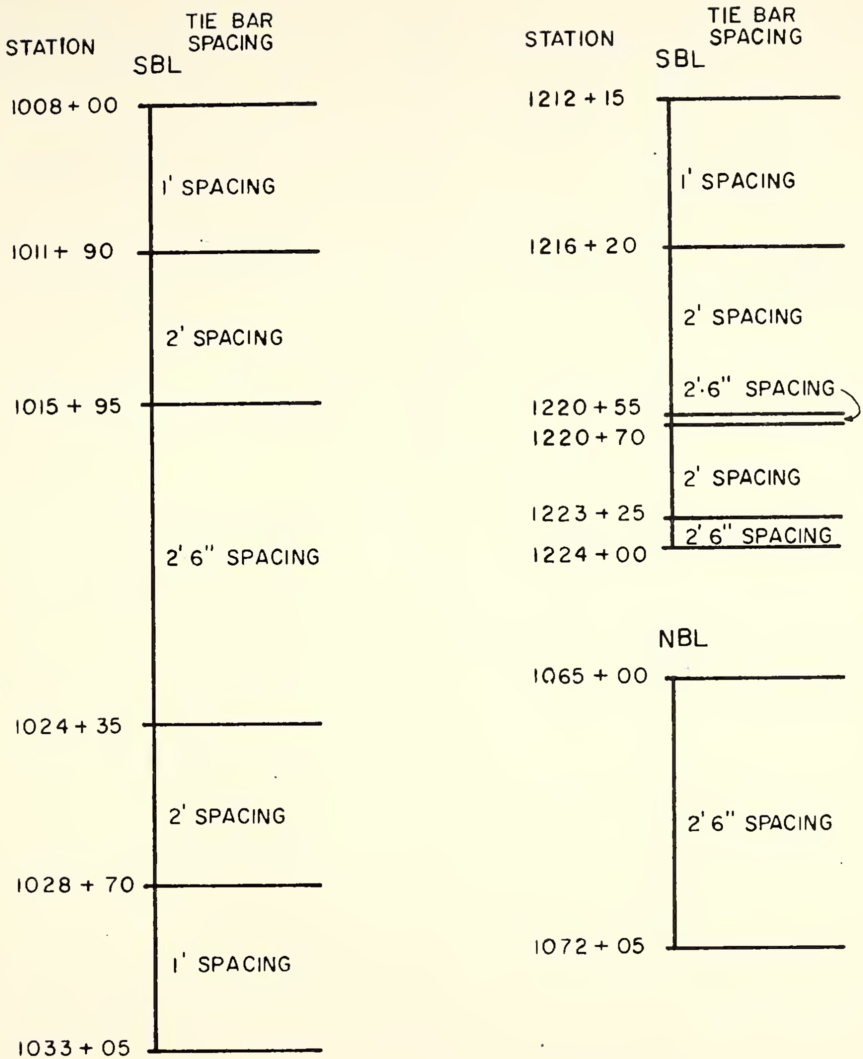


FIGURE 14. LAYOUT OF CONCRETE SHOULDERS

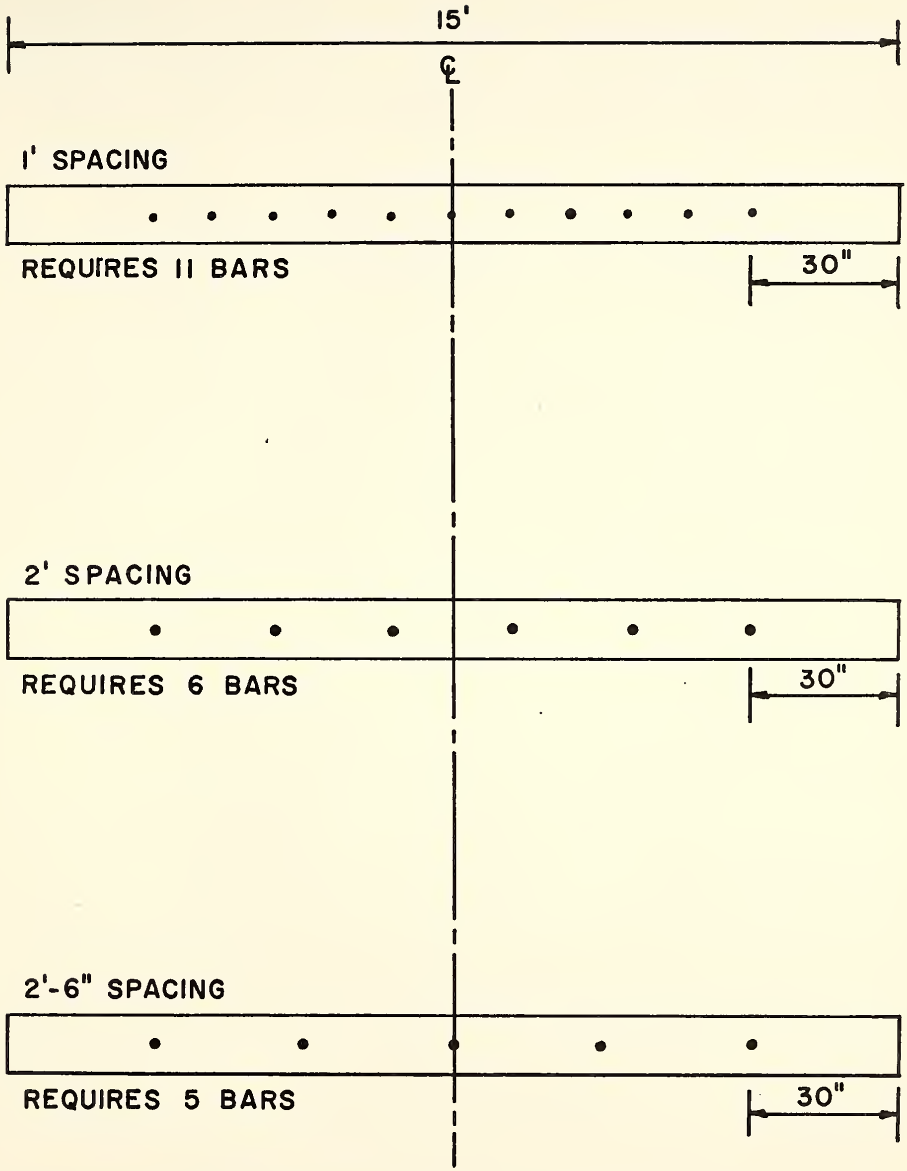


FIGURE 15. LAYOUT OF TIE BARS FOR CONCRETE SHOULDERS

bar holes. The holes were therefore redrilled and the unused holes were filled with mortar. Nevertheless, some deviation from the plans existed. The spacings that actually exist in the completed shoulder of Section "P" are as follows:

27 slabs	1212+15-1216+20	1' spacing
29 slabs	1216+20-1220+55	2' spacing
1 slab	1220+55-1220+70	2'6" spacing
17 slabs	1220+70-1223+25	2' spacing
5 slabs	1223+25-1224+00	2'6" spacing

Although some tie bar holes on South Bound lane 1008+00-1033+05 (Sections "E" and "F") were also drilled incorrectly when the problem was noticed at station 1212+15-1224+00, this was corrected by grouting the incorrect holes and this section was installed with the spacings as follows:

26 slabs	1008+00-1011+90	1' spacing
27 slabs	1011+90-1015+95	2' spacing
56 slabs	1015+95-1024+35	2'6" spacing
29 slabs	1024+35-1028+70	2' spacing
29 slabs	1028+70-1033+05	1' spacing

All slabs on NBL 1065+00-1072+05 (Sections "U" and "V") were installed with a 2'6" tie bar spacing.

2. It became apparent that difficulty would arise in the NBL 1138+00-1143+00 where both the concrete shoulder and an overlay were to be installed. In a three-way discussion between Purdue, ISHC,and FHWA personnel, it was decided that the concrete shoulder should be omitted at this location.

General Observations

1. About every other joint in the concrete shoulder cracked after about five days.

2. A small amount of honeycombing was noticed at the outside edge of the concrete shoulder in some locations (see Figure 16).

FIGURE 16. EXAMPLE OF HONEYCOMBING AT OUTER EDGE OF THE CONCRETE SHOULDER

3. Later in construction when the passing lane was closed, some drivers used the concrete shoulder at SBL 1008+00-1033+05 as a riding lane. It is presently not known whether this will continue after both lanes of the pavement are open, but earlier studies indicated it should not occur.

Subdrains

Since pumping of the pavement due to free water on top of the subbase is believed to be a major cause of distress, the use of subdrains to remove the water became an obvious type of maintenance to be used in the high deflection areas.

Although subdrains are typically installed approximately two feet from the pavement edge, they were installed directly adjacent to the pavement edge in this project. This was done to trap and remove the water from the top of the subbase as quickly as possible and to drain infiltration water between the pavement and shoulder directly (see Figure 17).

The backfill for the subdrains were carried up beyond the bottom edge of the pavement and to within 3 inches of the top of pavement. The top 3 inches was filled with asphalt concrete shoulder material. This procedure was followed to insure draining any water which might lie on top of the subbase.

Construction (Figures 18 to 22)

Subdrains were installed at the outside edge of the pavement at selected locations. Outlets for the drainage test sections were spaced at approximately 500' intervals where possible. The existing shoulder surface was first sawed to allow for excavation. The surface over the subdrain location was then removed with a backhoe. Installation of the subdrains required the complete removal of a trench through the shoulder, subbase, and subgrade to the

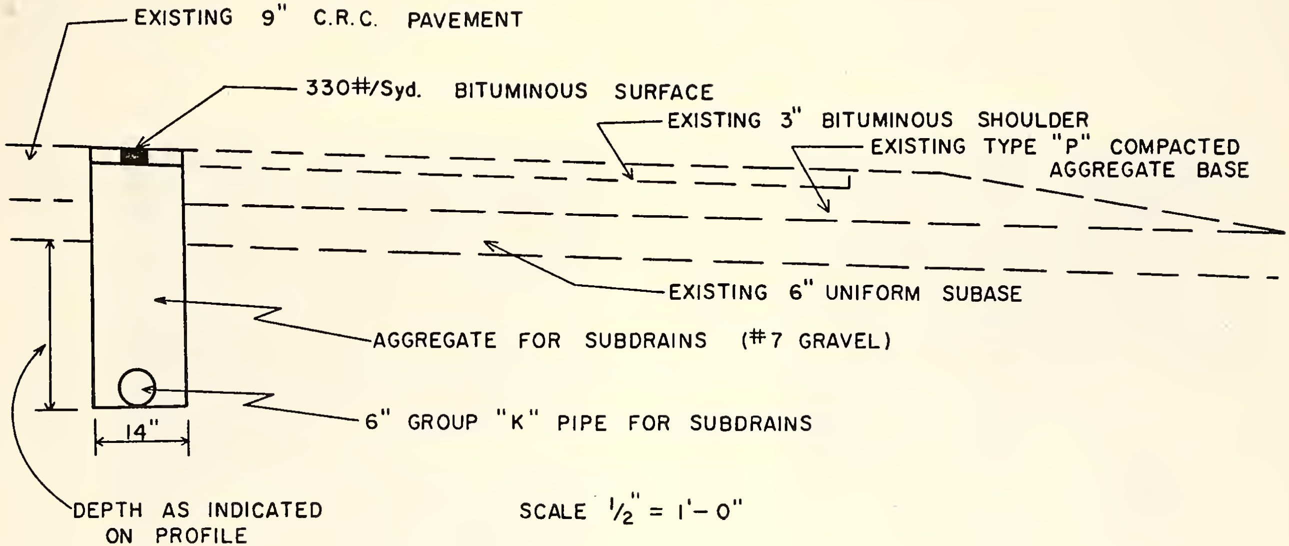


FIGURE 17. SUBDRAIN DETAILS ALONG OUTSIDE EDGE OF PAVEMENT

FIGURE 18. TRENCHING FOR SUBDRAINS

FIGURE 19. SUBDRAIN PIPE IN PLACE

FIGURE 20. BACKFILLING SUBDRAIN TRENCH

FIGURE 21. A THREE-INCH ASPHALT SHOULDER WAS PLACED OVER THE BACKFILL OF THE SUBDRAINS

FIGURE 22. SUBDRAIN OUTLET

depth indicated on the profile of the construction plans. This was accomplished with a rotary trenching machine, or in some cases a backhoe. The drain pipe was placed at the bottom of the trench directly from the truck. The trench was then backfilled with No. 7 gravel (see specification No. 903.02 in Appendix G) a permeable material taking care to avoid contamination of the trench by the subbase or subgrade material. The backfill was then overlayed with a 330 pound bituminous surface bringing the shoulder back to grade.

General Observations

1. Several days after the subdrains had been installed, water was noticed draining from the subdrains.
2. The subdrains were installed deeper than necessary for drainage of the subbase above and, hence, are possibly removing some groundwater as well as water from the subbase.

Undersealing

For many years, undersealing and mudjacking have been used as a means of filling cavities under a concrete pavement. Undersealing is accomplished by pumping hot asphalt under the pavement. In addition to the filling of voids, the asphalt forms a waterproof layer that assists in prevention of continued erosion of the subbase due to pumping.

Since pumping was considered to be one of the primary modes of failure for this pavement, undersealing (both with and without overlaying) was a major variable in the experimental layout.

The specifications for the undersealing material used in this project are given in Specification No. 902.06 of Appendix G.

Construction (Figures 23 to 26)

The pavement was undersealed with asphalt at specified locations. Two inch holes were drilled through the pavement in the right hand lane. The hot asphalt was then pumped through the hole until either the pavement or the shoulder lifted approximately 1/8"-1/4" as determined by a gauge resting on the shoulder (Figure 25). A two inch wooden pole was quickly inserted into the hole after pumping was completed. After the asphalt had cooled sufficiently, a two inch wooden plug was driven into the hole and the process continued.

Criteria for Spacing of Holes

When the undersealing operation first began, the proper spacing of the holes was not known. The criteria shown in Figures 27 through 31 were originally used in SBL 1171+00-1141+00 which was the first section undersealed. In general, one row of holes spaced 8' c-c was used at locations where deflections were greater than 0.9 mils with uniform crack spacing. Two rows staggered every four feet were used in locations with high deflections and closely spaced cracking (Figure 29), and each side of potential failures or patches (Figures 30 and 31).

After several sections were undersealed, it was decided that just one row of holes 8' c-c in the centerline of the right lane was needed since the asphalt was traveling across and coming out the staggered holes. For the remainder of the undersealed areas, the same criteria as before was used, but only one row was used where two rows were called for. The final quantities of undersealing are shown in Table 4. The number and location of holes drilled and other pertinent data are shown in Appendix E.

FIGURE 23. DRILLING HOLES FOR UNDERSEALING

FIGURE 24. OVERALL VIEW OF UNDERSEALING OPERATION

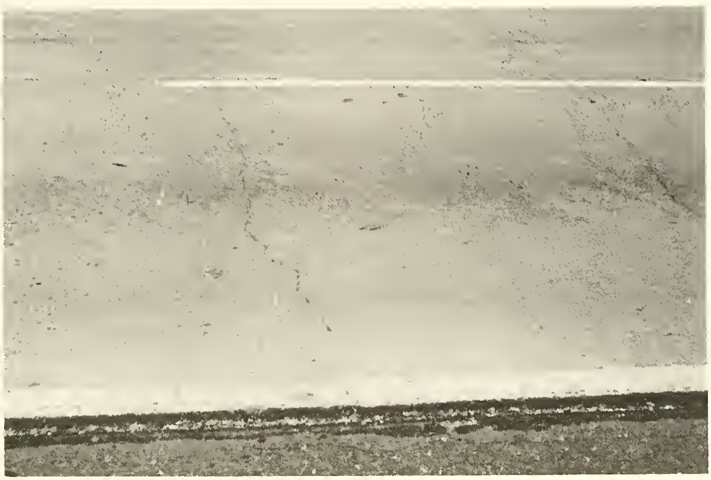
FIGURE 25. GAUGE FOR MEASURING POSSIBLE RISE OF PAVEMENT OR SHOULDER

FIGURE 26. PLUGGING UNDERSEALING HOLE

CHARACTERISTICS: UNIFORM CRACK SPACING (3'- 4') WITH DEFLECTIONS LESS THAN 0.9 MILS.

UNDERSEAL HOLE SPACING: NO HOLES REQUIRED.

NOTE: CATEGORY IC HAD THE SAME CHARACTERISTICS AS CATEGORY I, BUT HAD I ROW OF HOLES IN THE CENTERLINE OF TRAFFIC LANES AT 8' C-C.



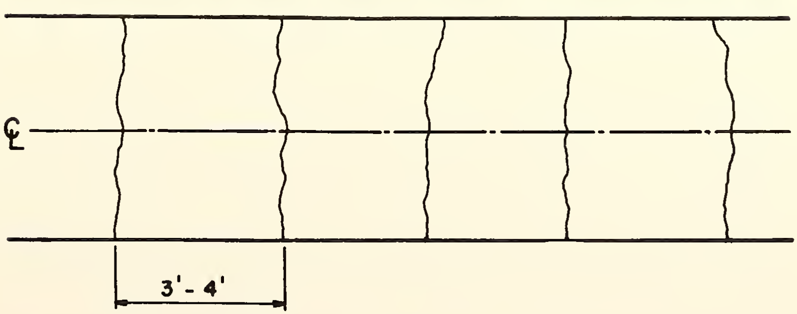
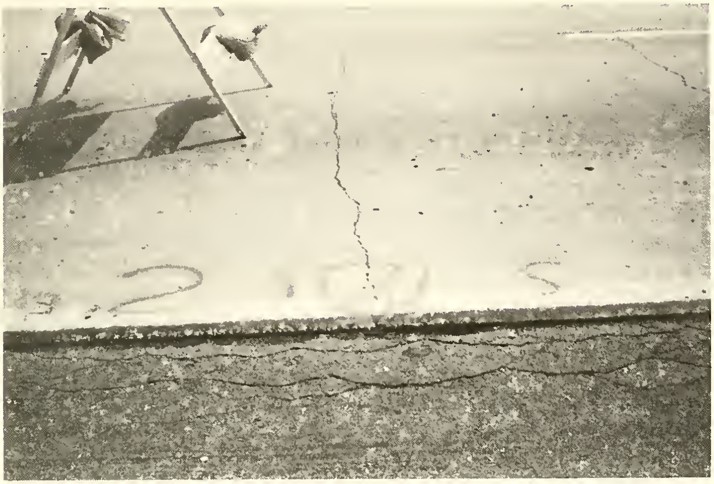


FIGURE 27. UNDERSEALING CRITERIA, CATEGORY I & IC

CHARACTERISTICS: UNIFORM CRACK SPACING WITH DEFLECTIONS GREATER THAN 0.9 MILS.

UNDERSEAL HOLE SPACING: 4' FROM OUTSIDE PAVEMENT EDGE AT 8' C-C.



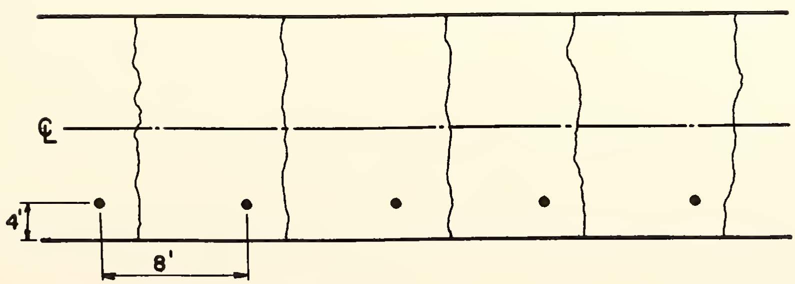


FIGURE 28. UNDERSEALING CRITERIA, CATEGORY 2

CHARACTERISTICS: RANDOM CRACKS AND INTERSECTING CRACKS SPACED AT LESS THAN 30" WITH DEFLECTIONS GREATER THAN 0.9 MILS.

UNDERSEAL HOLE SPACING: 2 ROWS 8' C-C, STAGGERED.

NOTE: CATEGORY 4 HAD THE SAME CHARACTERISTICS AS CATEGORY 3, BUT WITH EDGE PUMPING.

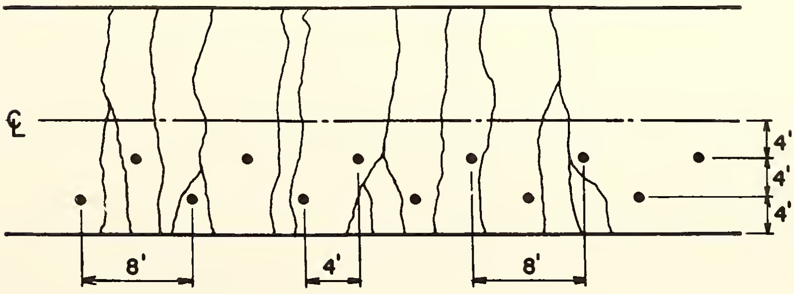


FIGURE 29. UNDERSEALING CRITERIA, CATEGORY 3 & 4

CHARACTERISTICS: POTENTIAL FAILURES.

UNDERSEAL HOLE SPACING: 2 ROWS 8' C-C, STAGGERED, AND EXTENDED AT LEAST 8' BEYOND EACH END OF POTENTIAL FAILURE.

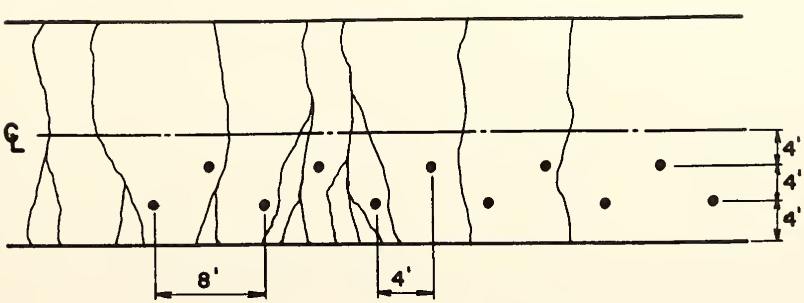


FIGURE 30. UNDERSEALING CRITERIA, CATEGORY 5

CHARACTERISTICS: BOTH OLD AND NEW PATCHES.

UNDERSEAL HOLE SPACING: 4 HOLES (SEE SKETCH BELOW).

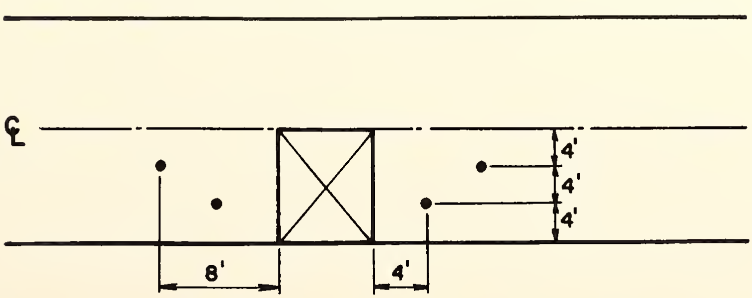


FIGURE 31. UNDERSEALING CRITERIA, CATEGORY 6

TABLE 4. QUANTITIES OF UNDERSEALING MATERIAL

Day	No. of Holes Pumped	Weight of Asphalt Pumped
1	238	16.94 tons
2	224	11.76 tons
3	102	1.22 tons

General Observations

1. The asphalt at times found a weak spot in the shoulder and would raise it and pour out onto the shoulder and pavement before the gauge indicated movement. This was further complicated by the fact that the shoulder sometimes continued to rise after the pumping had stopped. An example of the asphalt raising the shoulder can be seen in Figure 32.

2. The contractor had difficulty with the pump on the third and last day of undersealing. It didn't seem to be pumping under enough pressure. After a couple of minutes at each hole, the state highway personnel would stop them and go to the next hole. The quantities of undersealing pumped each day (Table 4) indicate that very little asphalt was pumped on the last day.

3. When the pump was working properly, as much as 50 gallons was pumped in a given hole when calculated at the rate of 30 gals/min.

4. The quantities of asphalt pumped under the pavement indicated there were large voids under the pavement. When the pavement at station 1088+20 on the South bound lane was patched, it had already been undersealed (Figure 33). The undersealing was found to be continuous throughout the patch and ranged in thickness from 1/8" to 3/8".

FIGURE 32. VIEW OF A SECTION OF SHOULDER THAT HEAVED DURING THE UNDERSEALING OPERATION

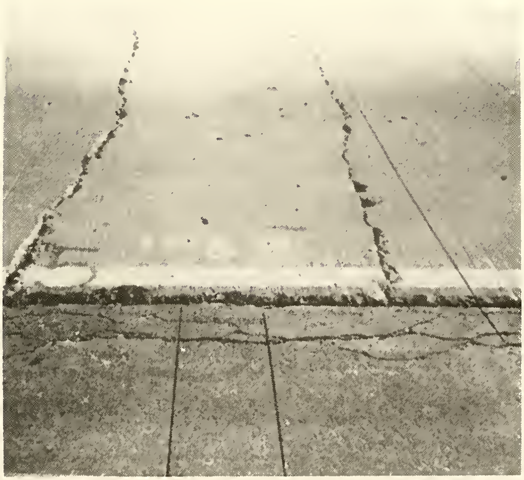


FIGURE 33. POTENTIAL FAILURE UNDERSEALED ON SBL AT STATION 1088+20. THIS CONCRETE WAS LATER REMOVED AND REPLACED WITH A CONCRETE PATCH.

Asphalt Concrete Overlay

Asphalt concrete overlays can be used to correct both surface irregularities and structural deficiencies. On this project, the overlay was intended to improve the structural adequacy of the existing CRC pavement and to reduce deflection.

It is not known if the high deflection of CRC pavements will permit use of thin overlays, nor is it known how thick the optimum overlay should be. Therefore, thickness of overlay was a major variable of this study. The asphalt concrete overlays were constructed with materials in accordance with standard Indiana specifications as outlined in Appendix G. A Type IV emulsion asphalt anti-skid treatment was included in all overlayed pavements.

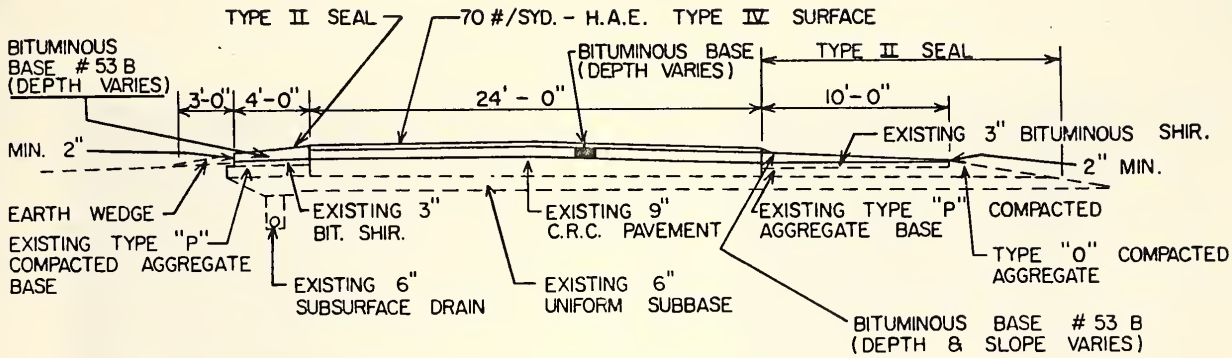
The reader is referred to Figure 6 for the general layout of the overlay sections.

Construction (Figures 34 to 36)

The existing pavement was overlayed with asphaltic concrete at specified locations. A bituminous base of 370#/syd (or approximately 3") (Figure 34) was used at all locations except the longest overlay at NBL 1082+00 to 1152+00 (Sections "X" to "BB" on Figure 6). In this section an overlay "wedge" was formed by varying the base thickness as shown below:

NBL 1082+00-1110+00	220#/syd. (approx. 2")
NBL 1110+00-1119+00	370#/syd. (approx. 3")
NBL 1119+00-1129+00	550#/syd. (approx. 5")
NBL 1129+00-1152+00	370#/syd. (approx. 3")

This operation was performed by installing 1" of bituminous base where 3" was required, 3" of bituminous base where 5" was required, and then adding 2" of base over the entire section giving the required thicknesses throughout the wedge.



SCALE: $\frac{1}{8}" = 1'-0"$

FIGURE 34. ASPHALTIC CONCRETE OVERLAY DETAILS

FIGURE 35. ASPHALT CONCRETE OVERLAY AT THE WEDGE SECTION

FIGURE 36. ASPHALT OVERLAY AT RAMP AREA

The existing shoulders were overlayed with a No. 53B bituminous base to the required depth. Type "O" compacted aggregate was placed at the outside edge of the shoulder and an earth wedge was placed at the inside of the median side shoulder to meet the existing ground.

The bituminous base was finally overlayed with a 70 pound Type IV emulsion surface and the shoulders were sealed with a Type II sealant to complete the overlays.

Changes During Construction

The installation of the Type IV emulsion surface required an outside temperature of 60^{o}F and rising. Due to the fact that construction of the overlays extended into late fall, the possibility of having this temperature situation became slim. Therefore, the emulsion surface was not placed over all the overlay sections but will be installed in the spring of 1976. All the base, however, has been installed and will be used as a riding surface through the winter of 1975-1976.

Concrete Patching

Concrete patching was required in all sections for the permanent repair of isolated locations of structurally damaged or failed areas. The experiment required that any location where a breakup had occurred must be patched in addition to any other maintenance that was used, to fully receive the benefit of the maintenance.

It should be noted in Figure 6, that several "No Maintenance" sections existed. These sections were those where no failures existed at the time of construction. In other words, concrete patching was always done at failed locations, even in the control sections, and these no maintenance sections were those that had no defects.

All concrete patching was done in accordance with the supplemental specifications outlined in Appendix G.

Construction (Figures 37 to 43)

At the site to be patched, four grooves were first cut in the pavement. The first two cuts were about 2 inches deep at the outsides of the area to be patched. The second two cuts were to a depth of 5 or 6 inches. These cuts were 3 feet in from the outside edge of the potential patch to cut the steel reinforcements. This left 3 feet of steel on each end of the patch to tie to the new reinforcing steel as seen in Figure 40. All patches were one lane wide (12 feet).

After sawing, the failure was broken out with a tractor mounted jackhammer and the concrete was removed by hand. The subbase was then leveled, backfilled if necessary, and compacted (Figure 41). Number 5 reinforcing bars were then tied to the existing longitudinal No. 4 bars and set on chairs. Transverse bars were tied to the longitudinal bars at about 3' intervals to keep the longitudinal bars stationary during the pouring of the patch.

The patches were poured directly from the concrete truck. They were then vibrated with a hand held vibrator, leveled off, brushed, and left to cure.

French drains (Figure 43) were installed, if possible, at each patch to allow for quick drainage of the patched area.

Appendix E shows the locations and sizes of patched areas.

Areas of potential failure were judged individually by the ISHC project engineer. Some of the potential failures were patched and some were left unpatched depending on his judgement as to the extent of damage.

FIGURE 37. SAWING PAVEMENT FOR PATCH

FIGURE 38. BREAKING OUT EXISTING PAVEMENT

FIGURE 39. REMOVING CONCRETE FROM FAILED AREA

FIGURE 40. EXISTING PAVEMENT REMOVED FROM FAILED AREA. NOTE REINFORCING STEEL.

FIGURE 41. THE SUBBASE WAS RECOMPACTED BY MEANS OF A VIBRATOR PRIOR TO PATCHING

FIGURE 42. INSTALLING NEW STEEL BEFORE POURING CONCRETE PATCH

FIGURE 43. TRENCH FOR FRENCH DRAINS

At SBL 1146+75, a considerable amount of unconsolidated concrete was found in the passing lane when the failure was removed in the right lane. As little as 2" of the pavement was consolidated in some places with the remaining 7" being no more than aggregate as seen in Figure 44.

Full Depth Bituminous Patching

The reasons for full depth bituminous patching are the same as those for concrete patching. Full depth patching was included to compare the effect of bituminous patching with that of concrete patching. Just a minimal amount of this maintenance was used.

The full depth bituminous patches were constructed similar to the concrete patches, however, all the existing steel within the patched area was removed along with the concrete to the pavement depth. After compacting the subbase, #5 asphalt base was installed with a Type B surface bringing the patch back to the existing grade. Supplemental specifications for bituminous patching are shown in Appendix G.

FIGURE 44. UNCONSOLIDATED CONCRETE PAVEMENT IN PASSING LANE AT STATION 1146+75 OF THE SOUTH BOUND LANE

EVALUATION METHODS

Preliminary evaluation of the maintenance methods were made using two basic techniques: (1) deflection measurements using the Dynaflect and (2) condition surveys in which the extent of cracking and failures were determined.

Both types of surveys were made on four occasions (1) Fall 1974, (2) Spring 1975, (3) Summer of 1975 just prior to construction and (4) Fall of 1975 immediately after construction. These data are presented in Appendix A of this report. It is proposed to continue both surveys at intervals for the first two years following construction to further evaluate the effects of the maintenance.

In addition, surveys will be made at frequent intervals as needed after the end of this research project. Proposed extensions to this specific proposal will be required. However, the extent, intensity and need for future surveys will be re-evaluated after the first two years of exposure to traffic.

It is recognized that the evaluation of the maintenance methods must extend over a wide span of years. This will be done, but, the extent of this last phase will be determined after an initial period of two years of traffic. It may be necessary to change evaluation methods at a later date, thus necessitating the need to await the initial first two years of traffic.

This research project, then is divided into three phases (1) construction, (2) evaluation for two years and (3) future evaluation to be determined after the 2nd phase.

Further samples of the subbase and subgrade were obtained during construction. These data will also be evaluated after laboratory tests are completed.

The construction records (control tests etc.) will be obtained and will be used in further analysis. No attempt has been made up to the time of preparation of this report to evaluate tests made on samples obtained during construction or on control test data (i.e., grain size distribution, asphalt content, etc.).

This later phase needs to await completion of all construction in the spring of 1976.

Analysis will also include maintenance required during the next several years.

SUMMARY OF INITIAL EFFECTS OF CONSTRUCTION

This section presents some of the initial comparisons that can be made at this time. Specific conclusions cannot be made or inferred at this time, since it will take some time after the construction of the maintenance to fully evaluate its effect. The preliminary analysis can only serve as a guide to help the reader determine what maintenance methods might be appropriate for a given set of conditions. Final conclusions as to the effects of the respective maintenance techniques will not be made until the completion of Phase III of this project.

One of the maintenance sections on the south bound lane, (Section "U") at 1065+00-1066+00 will be omitted from all comparisons because of its short length which was necessitated by an extension of subdrains made during construction. Section "U" is considered to be a special exception in this research.

The Effects of Different Types of Maintenance On Given Initial Rating Numbers

Tables B1 thru B11 in Appendix B show the effects of the different types of maintenance on the deflections of pavement sections with initial ratings of 1 through 12. The statistic $\bar{x} + \sigma$ of the deflections and the average patching per 100' are listed for three different periods: (1) the Fall of 1974; (2) the Summer of 1975 (just prior to construction); and (3) the Fall of 1975 (immediately after construction).

Several comments must be made at this time:

1. Some patching of breakups was done between the Fall of 1974 and the start of this construction project. This patching is indicated in the Summer 1975 data and is also included in the Fall 1975 patching quantities.
2. Patching of breakups was carried out in all maintenance sections except the "no maintenance areas" unless indicated otherwise.
3. Deflection measurements were not taken in the Fall of 1974 on maintenance section "R" and part of "S" between NBL 990+00 and 1008+00. For these sections, the Spring 1975 data were used and recorded in the Fall 1974 column.
4. There were no maintenance sections with an initial rating of 3.

It is believed that any analysis of the data at time of preparation of this report would be premature. The data in Appendix B suggest that reduction in deflection resulted from all of the treatments. Nevertheless, measurements made after one winter of traffic should begin to show up differences in performance.

Likewise, the cost data presented in Appendix D must be treated with discretion since they reflect the unit bid prices for this specific job. Future analysis may include comparisons based on average prices as tabulated by the Indiana State Highway Commission. Even so, this must be done on a cost effective basis which must of necessity include relative performance of the various maintenance types.

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APPENDICES

APPENDIX A

SUMMARY OF FIELD SURVEY DATA

TABLE AI. SUMMARY OF TEST RESULTS ON SOUTH BOUND LANE*

STATIONS	AVG. BREAKUPS 100' SECTION				AVG. CRACKING 100' SECTION				DEFLECTION AVG.				AVG. PATCHING 100' SECTION			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
990- 995	0	0	0	0	11.2	17.0	19.8	19.4	.55	.71	.73	.77	0	0	0	0
995- 996	80.0	92.0	92.0	0	27.0	26.0	28.0	15.0	.77	1.11	1.12	1.34	0	0	0	288.0
996-1001	0	0	0	0	12.8	12.6	15.2	15.4	.74	.73	.75	.85	0	0	0	0
1001-1008	20.4	38.0	40.9	0	20.9	21.6	23.4	17.7	.92	1.20	1.13	.93	0	0	0	169.7
1008-1013	14.4	19.2	21.2	0	27.2	26.0	25.6	22.8	1.11	1.01	.86	.86	0	0	0	48.0
1013-1018+50	59.6	59.3	59.3	0	39.3	38.0	38.4	33.5	1.00	1.18	.96	.68	0	0	0	120.0
1018+50-1024	28.2	34.5	38.0	0	62.2	58.4	33.1	26.4	1.41	.99	.93	.60	0	0	0	104.7
1024-1033	9.0	12.4	17.3	0	20.2	19.9	19.3	15.3	1.00	.96	.92	.68	0	0	0	50.7
1033-1036	38.7	2.7	2.7	0	19.3	10.7	9.0	11.5	1.00	.83	.80	.60	0	120.0	120.0	120.0
1036-1042	9.7	0	0	0	12.3	11.0	12.8	OVER-LAY	1.27	.83	.75	.58	0	36.0	36.0	36.0
1042-1050	7.6	2.6	2.6	0	13.1	14.0	12.1		.99	.75	.76	.49	0	2.6	2.6	66.8

*SEE LAST PAGE OF TABLE FOR NOTES.

TABLE AI, CONTINUED*

STATIONS	AVG. BREAKUPS 100' SECTION				AVG. CRACKING 100' SECTION				DEFLECTION AVG.				AVG. PATCHING 100' SECTION			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
1050-1053	25.3	0	0	0	16.0	19.3	18.0	21.5	1.18	.81	.85	.53	0	92.0	92.0	124.0
1053-1059	0	0	0	0	5.7	8.3	8.5	7.7	1.19	.79	.77	.52	0	0	0	0
1059-1062	40.0	0	0	0	19.0	18.7	19.3	22.0	1.03	.77	.75	.61	0	108.0	108.0	108.0
1062-1070	1.1	1.5	1.5	0	6.3	8.6	8.5	8.9	1.39	.82	.75	.67	0	1.5	1.5	9.0
1070-1080	0	0	0	0	11.8	11.4	11.5	13.3	.62	.78	.71	.63	0	0	0	0
1080-1090	4.5	4.6	4.6	0	14.4	16.2	15.5	17.3	.59	.81	.81	.62	0	0	0	30.0
1090-1100	14.4	16.8	16.8	0	12.6	13.6	12.6	11.9	.77	1.17	1.03	.90	0	0	0	32.4
1100-1110	4.5	4.5	4.5	0	15.2	16.4	15.9	17.6	.81	.83	.91	.84	0	0	0	14.4
1110-1115	1.6	2.0	2.0	0	14.0	11.2	14.0	15.2	.83	.87	.92	.87	0	0	0	21.6
1115-1127	0.4	8.3	8.3	0	9.9	10.0	12.3	13.0	.83	.98	.89	.99	0	0	0	25.0
1127-1131	11.0	14.5	14.5	0	15.3	14.8	16.0	16.0	.84	1.08	.87	1.13	0	0	0	69.0
1131-1141	3.0	4.6	4.6	0	13.7	13.9	14.8	15.3	.76	.94	.87	1.02	0	0	0	19.2

*SEE LAST PAGE OF TABLE FOR NOTES.

TABLE AI, CONTINUED*

STATIONS	AVG. BREAKUPS 100' SECTION				AVG. CRACKING 100' SECTION				DEFLECTION AVG.				AVG. PATCHING 100' SECTION			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
1141-1151	0.6	1.5	1.5	0	8.8	11.0	12.0	OVERLAY	.80	.99	.94	.88	0	0	0	10.8
1151-1161	0	1.2	1.2	0	10.2	11.1	12.3		.91	1.05	1.03	.84	0	0	0	16.8
1161-1171	0	0.1	0.1	0	10.9	9.6	11.5		.92	.91	1.15	.57	0	0	0	4.8
1171-1181	1.2	2.2	2.2	0	20.0	17.0	20.1	20.2	.84	.76	1.16	.81	0	0	0	20.4
1181-1190	0	2.4	2.4	0	21.1	18.4	20.3	21.0	.90	.75	1.17	.91	0	0	0	18.7
1190-1196	0	1.0	1.0	0	17.3	17.7	21.2	20.0	.57	.59	.90	.77	0	0	0	8.0
1196-1204	25.5	29.0	29.0	0	26.3	23.1	29.9	23.9	.96	.72	.99	.69	0	0	0	76.5
1204-1209	0	0	0	0	23.6	21.0	23.8	22.2	.69	.59	1.03	.72	0	0	0	0
Bridge	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1212-1224	12.3	13.1	13.6	0	34.1	28.8	35.0	29.5	.80	.77	1.08	.66	0	0	0	102.0
1224-1229	33.6	35.4	48.0	0	52.0	45.2	46.8	43.8	.72	.64	1.08	.85	0	0	0	108.0
1229-1235	0.5	4.3	4.3	0	28.7	22.2	23.3	28.3	.81	.79	.95	.82	0	0	0	48.0

* SEE LAST PAGE OF TABLE FOR NOTES.

TABLE A1, CONTINUED

NOTES:

1. A = FALL 1974, B = SPRING 1975, C = SUMMER 1975, AND D = FALL 1975.
2. FULL DEPTH BITUMINOUS AND CONCRETE PATCHING IS NOT INCLUDED IN AREAS OF BREAKUPS.
3. CRACKING INCLUDES INTERSECTING, PARALLEL AND COMBINATION CRACKS.
4. PATCHING AREAS MAY BE CONCRETE OR BITUMINOUS. BITUMINOUS PATCHING AREAS ARE CIRCLED.

TABLE A2. SUMMARY OF TEST RESULTS ON NORTH BOUND LANE*

STATIONS	AVG. BREAKUPS 100' SECTION				AVG. CRACKING 100' SECTION				DEFLECTION AVG.				AVG. PATCHING 100' SECTION			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
990- 994	0	0	0	0	24.0	23.5	30.0	31.5	-	.79	.77	.58	0	0	0	0
994- 999	26.8	0	0	0	34.4	32.0	32.4	35.0	-	.78	.96	.62	0	7.2 86.4	7.2 86.4	7.2 103.2
999-1008	4.1	0.9	1.9	0	11.6	12.4	11.8	13.8	-	.88	.72	.60	0	4.0 18.7	4.0 18.7	4.0 37.3
1008-1019	4.9	0	3.3	0	12.3	11.5	12.6	9.8	1.04	.72	.71	.59	0	3.3 38.2	3.3 38.2	3.3 115.6
1019-1025	0	1.0	1.0	0	13.7	15.3	14.5	14.2	.55	.65	.71	.50	0	0	0	16.0
1025-1039	10.6	2.4	2.4	0	24.1	24.3	23.5	24.1	.83	.77	.96	.61	0	10.3 42.9	10.3 42.9	10.3 79.7
1039-1047	22.1	1.5	1.5	0	29.0	18.4	16.3	16.8	1.28	.75	.92	.59	0	11.9 199.5	11.9 199.5	7.5 225.0
1047-1054	13.0	0	0	0	14.6	15.1	15.7	15.9	1.07	.85	.95	.75	0	60.0	60.0	60.0
1054-1063	0	0	0	0	14.7	16.6	15.8	17.1	1.08	.90	1.01	.65	0	6.7	6.7	6.7
1063-1065	8.0	0	0	0	38.0	41.0	39.5	44.5	.46	.80	.95	.64	0	126.0	126.0	126.0
1065-1066	0	0	0	0	52.0	54.0	57.0	54.0	1.24	.89	.85	.72	0	0	0	0

*SEE LAST PAGE OF TABLE FOR NOTES.

TABLE A2, CONTINUED*

STATIONS	AVG. BREAKUPS 100' SECTION				AVG. CRACKING 100' SECTION				DEFLECTION AVG.				AVG. PATCHING 100' SECTION			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D.
1066-1070	0	3.0	3.0	0	36.0	37.5	35.0	39.8	.93	.98	.99	.78	0	0	0	39.0
1070-1072	17.0	0	0	0	36.0	30.5	30.5	35.5	.72	.84	.82	.54	0	144.0	144.0	144.0
1072-1082	4.3	0	0	0	16.6	15.6	18.2	18.6	.86	.84	.94	.64	0	46.8	46.8	46.8
1082-1092	1.0	3.8	3.8	0	12.8	17.0	17.4		1.01	.77	.83	.54	0	(10.8) 15.6	(10.8) 15.6	(10.8) 44.4
1092-1101	5.4	0	0	0	14.1	15.9	13.8		1.03	.73	.80	.57	0	46.7	46.7	46.7
1101-1108	41.0	1.1	1.1	0	32.7	33.7	29.3		.82	.76	.81	.45	0	87.4	87.4	(13.7) 87.4
1108-1118	0	0	0	0	16.0	15.0	15.8		.99	.89	.90	.51	0	0	0	0
1118-1131	11.2	0	0	0	28.4	24.2	23.3	OVERLAY	.80	.78	.82	.44	0	65.5	65.5	65.5
1131-1138	43.4	3.1	3.1	0	47.1	36.3	44.9		.66	.75	.80	.57	0	96.6	96.6	110.3
1138-1143	65.2	0.2	0.2	0	39.8	31.2	42.0		1.21	.70	.81	.54	0	178.8	178.8	217.2
1143-1148	5.0	0	0	0	21.8	13.6	19.6		.66	.68	.71	.45	0	33.6	33.6	33.6
1148-1152	49.5	3.0	3.0	0	24.5	14.8	23.0		1.09	.78	.89	.50	0	126.0	126.0	144.0

* SEE LAST PAGE OF TABLE FOR NOTES.

TABLE A2, CONTINUED*

STATIONS	AVG. BREAKUPS 100' SECTION				AVG. CRACKING 100' SECTION				DEFLECTION AVG.				AVG. PATCHING 100' SECTION			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
1152-1161	0	0	0	0	13.9	10.4	15.3	16.1	.85	.76	.89	.69	0	0	0	0
1161-1165	0	0	0	0	39.5	35.5	42.8	42.5	.85	.78	.86	.74	0	0	0	0
1165-1167	24.0	0	0	0	57.5	38.0	42.5	37.0	.86	.63	.73	.82	0	50.0	50.0	50.0
1167-1172	0	0	0	0	59.4	38.8	48.4	46.6	1.07	.82	.93	.85	0	0	0	0
1172-1176	0	0	0	0	63.3	45.8	54.8	52.5	.91	.77	.82	.82	0	0	0	0
1176-1189	27.3	4.8	4.8	0	40.2	26.8	35.2	31.6	.80	.77	.68	.53	0	94.1	94.1	124.5
1189-1201	2.0	4.5	4.5	0	27.6	26.8	33.7	29.6	.53	.91	.66	.57	0	0	0	64.0
1201-1209	0	2.3	2.3	0	23.8	22.6	26.1	24.9	.85	.74	.79	.63	0	0	0	37.5
Bridge	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1212-1225	0	2.2	2.5	0	34.9	31.2	36.2	OVERLAY	.89	1.01	.82	.57	0	0	0	19.4
1225-1235	7.7	3.7	5.1	0	20.3	20.8	24.5		1.03	.74	.83	.52	0	0	0	19.2

* SEE LAST PAGE OF TABLE FOR NOTES.

TABLE A2, CONTINUED

NOTES:

1. A = FALL 1974, B = SPRING 1975, C = SUMMER 1975, AND D = FALL 1975.
2. FULL DEPTH BITUMINOUS AND CONCRETE PATCHING IS NOT INCLUDED IN AREAS OF BREAKUPS.
3. CRACKING INCLUDES INTERSECTING, PARALLEL AND COMBINATION CRACKS.
4. PATCHING AREAS MAY BE CONCRETE OR BITUMINOUS. BITUMINOUS PATCHING AREAS ARE CIRCLED.

APPENDIX B

CHANGE IN DEFLECTION AND PATCHING CATEGORIZED BY ORIGINAL RATING NUMBER

TABLE BI. SECTIONS WITH ORIGINAL RATING OF I

LANE	STATION	DEFLECTION (AVG. + σ)			MAINTENANCE	PATCHING (AVG. / 100')		
		FALL '74	SUM. '75	FALL '75		FALL '74	SUM. '75	FALL '75
SBL	990 – 995	.55	.73	.77	NO MAINTENANCE	0.0	0.0	0.0
SBL	996 – 1001	.74	.75	.85	NO MAINTENANCE	0.0	0.0	0.0
SBL	1070 – 1080	.62	.71	.63	NO MAINTENANCE	0.0	0.0	0.0
SBL	1190 – 1196	.57	.90	.77	PATCHING ONLY	0.0	0.0	8.0
NBL	1019 – 1025	.55	.71	.50	PATCHING ONLY	0.0	0.0	16.0
NBL	1152 – 1161	.85	.89	.69	NO MAINTENANCE	0.0	0.0	0.0

TABLE B2. SECTIONS WITH ORIGINAL RATING OF 2

LANE	STATION	DEFLECTION (AVG. + σ)			MAINTENANCE	PATCHING (AVG. / 100')		
		FALL '74	SUM. '75	FALL '75		FALL '74	SUM. '75	FALL '75
SBL	1080 - 1090	.59	.81	.62	UNDERSEAL	0.0	0.0	30.0
SBL	1090 - 1100	.77	1.03	.90	PATCHING ONLY	0.0	0.0	32.4
SBL	1100 - 1110	.81	.91	.84	PATCHING ONLY	0.0	0.0	14.4
SBL	1110 - 1115	.83	.92	.87	PATCHING ONLY	0.0	0.0	21.6
SBL	1115 - 1127	.83	.89	.99	PATCHING ONLY	0.0	0.0	25.0
SBL	1127 - 1131	.84	.87	1.13	PATCHING ONLY	0.0	0.0	69.0
SBL	1131 - 1141	.76	.87	1.02	PATCHING ONLY	0.0	0.0	19.2
SBL	1141 - 1151	.80	.94	.88	UNDERSEAL & OVERLAY (3")	0.0	0.0	10.8
NBL	999 - 1008	.88	.72	.60	PATCHING ONLY	0.0	4.0 18.7	4.0 37.3
NBL	1072 - 1082	.86	.94	.64	PATCHING ONLY	0.0	46.8	46.8

TABLE B3. SECTIONS WITH ORIGINAL RATING OF 4

LANE	STATION	DEFLECTION (AVG. + σ)			MAINTENANCE	PATCHING (AVG. / 100')		
		FALL '74	SUM. '75	FALL '75		FALL '74	SUM. '75	FALL '75
SBL	1053-1059	1.19	.77	.52	SUBDRAINS (NO PATCHING)	0.0	0.0	0.0
SBL	1151 - 1161	.91	1.03	.84	UNDERSEAL & OVERLAY (3")	0.0	0.0	16.8
SBL	1161 - 1171	.92	1.15	.57	UNDERSEAL & OVERLAY (3")	0.0	0.0	4.8
NBL	1054 - 1063	1.08	1.01	.65	SUBDRAINS	0.0	6.7 0.0	6.7 0.0
NBL	1108 - 1118	.99	.90	.51	OVERLAY (3") (NO PATCHING)	0.0	0.0	0.0

TABLE B4. SECTIONS WITH ORIGINAL RATING OF 5

LANE	STATION	DEFLECTION (AVG. + σ)			MAINTENANCE	PATCHING (AVG. / 100')		
		FALL '74	SUM. '75	FALL '75		FALL '74	SUM. '75	FALL '75
SBL	1036 – 1042	1.27	.75	.58	UNDERSEAL & OVERLAY (3")	0.0	36.0	36.0
SBL	1042 – 1050	.99	.76	.49	UNDERSEAL & OVERLAY (3")	0.0	2.6	66.8
SBL	1062 – 1070	1.39	.75	.67	UNDERSEAL	0.0	1.5	9.0
NBL	1008 – 1019	1.04	.71	.59	PATCHING ONLY	0.0	3.3 38.2	3.3 115.6
NBL	1047 – 1054	1.07	.95	.75	SUBDRAINS	0.0	60.0	60.0
NBL	1082 – 1092	1.01	.83	.54	UNDERSEAL & OVERLAY (2")	0.0	10.8 15.6	10.8 44.4
NBL	1092 – 1101	1.03	.80	.57	UNDERSEAL & OVERLAY (2")	0.0	46.7	46.7

TABLE B5. SECTIONS WITH ORIGINAL RATING OF 6

LANE	STATION	DEFLECTION (AVG. + σ)			MAINTENANCE	PATCHING (AVG. / 100')		
		FALL '74	SUM. '75	FALL '75		FALL '74	SUM. '75	FALL '75
SBL	1033 – 1036	1.00	.80	.60	PATCHING ONLY	0.0	120.0	120.0
SBL	1050 – 1053	1.18	.85	.53	SUBDRAINS	0.0	92.0	124.0
SBL	1059 – 1062	1.03	.75	.61	UNDERSEAL	0.0	108.0	108.0

TABLE B6. SECTIONS WITH ORIGINAL RATING OF 7

LANE	STATION	DEFLECTION (AVG. + σ)			MAINTENANCE	PATCHING (AVG. / 100')		
		FALL '74	SUM. '75	FALL '75		FALL '74	SUM. '75	FALL '75
SBL	1204 – 1209	.69	1.03	.72	NO MAINTENANCE	0.0	0.0	0.0
NBL	990 – 994	.79	.77	.58	NO MAINTENANCE	0.0	0.0	0.0
NBL	994 – 999	.78	.96	.62	PATCHING ONLY	0.0	(7.2) 86.4	(7.2) 103.2
NBL	1161 – 1165	.85	.86	.74	SUBDRAINS (NO PATCHING)	0.0	0.0	0.0
NBL	1201 – 1209	.85	.79	.63	PATCHING ONLY	0.0	0.0	37.5
NBL	1212 – 1225	.89	.82	.57	OVERLAY (2")	0.0	0.0	19.4

TABLE B7. SECTIONS WITH ORIGINAL RATING OF 8

LANE	STATION	DEFLECTION (AVG. + σ)			MAINTENANCE	PATCHING (AVG. / 100')		
		FALL '74	SUM. '75	FALL '75		FALL '74	SUM. '75	FALL '75
SBL	1171 - 1181	.84	1.16	.81	PATCHING ONLY	0.0	0.0	20.4
SBL	1212 + 15 - 1224	.80	1.08	.66	CONCRETE SHOULDER	0.0	0.0	102.0
SBL	1229 - 1235	.81	.95	.82	PATCHING ONLY	0.0	0.0	48.0
NBL	1025 - 1039	.83	.96	.61	SUBDRAINS	0.0	(10.3) 42.9	(10.3) 79.7
NBL	1063 - 1065	.46	.95	.64	SUBDRAINS	0.0	126.0	126.0
NBL	1070 - 1072	.72	.82	.54	CONCRETE SHOULDER	0.0	144.0	144.0
NBL	1118 - 1131	.80	.82	.44	OVERLAY (5")	0.0	65.5	65.5
NBL	1143 - 1148	.66	.71	.45	UNDERSEAL & OVERLAY (3")	0.0	33.6	33.6
NBL	1189 - 1201	.53	.66	.57	PATCHING ONLY	0.0	0.0	64.0

TABLE B8. SECTIONS WITH ORIGINAL RATING OF 9

LANE	STATION	DEFLECTION (AVG. + σ)			MAINTENANCE	PATCHING (AVG. / 100')		
		FALL '74	SUM. '75	FALL '75		FALL '74	SUM. '75	FALL '75
SBL	995 – 996	.77	1.12	1.34	PATCHING ONLY	0.0	0.0	288.0
SBL	1224 – 1229	.72	1.08	.85	PATCHING ONLY	0.0	0.0	108.0
NBL	1101 – 1108	.82	.81	.45	OVERLAY (2")	0.0	87.4	13.7 87.4
NBL	1131 – 1138	.66	.80	.57	OVERLAY (3")	0.0	96.6	110.3
NBL	1165 – 1167	.86	.73	.82	SUBDRAINS	0.0	50.0	50.0
NBL	1176 – 1189	.80	.68	.53	PATCHING ONLY	0.0	94.1	124.5

TABLE B9. SECTIONS WITH ORIGINAL RATING OF 10

LANE	STATION	DEFLECTION (AVG. + σ)			MAINTENANCE	PATCHING (AVG. / 100')		
		FALL '74	SUM. '75	FALL '75		FALL '74	SUM. '75	FALL '75
SBL	1181 - 1190	.90	1.17	.91	PATCHING ONLY	0.0	0.0	18.7
NBL	1066 - 1070	.93	.99	.78	CONCRETE SHOULDER	0.0	0.0	39.0
NBL	1167 - 1172	1.07	.93	.85	UNDERSEAL (NO PATCHING)	0.0	0.0	0.0
NBL	1172 - 1176	.91	.82	.82	NO MAINTENANCE	0.0	0.0	0.0

TABLE B10. SECTIONS WITH ORIGINAL RATING OF 11

LANE	STATION	DEFLECTION (AVG. + σ)			MAINTENANCE	PATCHING (AVG. / 100')		
		FALL '74	SUM. '75	FALL '75		FALL '74	SUM. '75	FALL '75
SBL	1008 – 1013	1.11	.86	.86	CONCRETE SHOULDER	0.0	0.0	48.0
SBL	1024 – 1033	1.00	.92	.68	CONCRETE SHOULDER AND SUBDRAINS	0.0	0.0	50.7
NBL	1225 – 1235	1.03	.83	.52	OVERLAY (3")	0.0	0.0	19.2

TABLE B11. SECTIONS WITH ORIGINAL RATING OF 12

LANE	STATION	DEFLECTION (AVG. + σ)			MAINTENANCE	PATCHING (AVG. / 100')		
		FALL '74	SUM. '75	FALL '75		FALL '74	SUM. '75	FALL '75
SBL	1001 - 1008	.92	1.13	.93	PATCHING ONLY	0.0	0.0	169.7
SBL	1013 - 1018+50	1.00	.96	.68	CONCRETE SHOULDER	0.0	0.0	120.0
SBL	1018+50 1024	1.41	.93	.60	CONCRETE SHOULDER AND SUBDRAINS	0.0	0.0	104.7
SBL	1196 - 1204	.96	.99	.69	BITUMINOUS PATCHING	0.0	0.0	76.5 0.0
NBL	1039 - 1047	1.28	.92	.59	SUBDRAINS	0.0	11.9 199.5	7.5 225.0
NBL	1138 - 1143	1.21	.81	.54	OVERLAY & SUBDRAINS (3")	0.0	178.8	217.2
NBL	1148 - 1152	1.09	.89	.50	OVERLAY (3")	0.0	126.0	144.0

APPENDIX C

MAINTENANCE SECTIONS AND CORRESPONDING CONTROL SECTIONS

MAINTENANCE SECTIONS AND CORRESPONDING CONTROL SECTIONS

Table C1 shows the various maintenance sections with their corresponding "no maintenance" or "patching only" control sections. Maintenance sections with initial ratings or 4 or 11 have no control sections due to both length restrictions and changes made during construction such as extensions of maintenance types.

TABLE C1. MAINTENANCE SECTIONS AND CORRESPONDING CONTROL SECTIONS*

TYPE OF MAINTENANCE	MAINTENANCE SECTION (STATIONS)	CONTROL SECTION (STATIONS)
Concrete Shoulder	SBL 1008+00 - 1013+00	(See Note)**
	SBL 1013+00 - 1018+50	SBL 1001+00 - 1008+00
	SBL 1212+15 - 1224+00	SBL 1171+00 - 1181+00
		SBL 1229+00 - 1235+00
		NBL 1189+00 - 1201+00
	NBL 1066+00 - 1070+00	SBL 1181+00 - 1190+00
		NBL 1172+00 - 1176+00
	NBL 1070+00 - 1072+05	SBL 1171+00 - 1181+00
		SBL 1229+00 - 1235+00
		NBL 1189+00 - 1201+00
Concrete Shoulder and Subdrains	SBL 1018+50 - 1024+00	SBL 1001+00 - 1008+00
	SBL 1024+00 - 1033+05	(See Note)**
Subdrains	SBL 1050+00 - 1053+00	SBL 1033+00 - 1036+00
	SBL 1053+00 - 1059+00	(See Note)**
	NBL 1025+00 - 1039+00	SBL 1171+00 - 1181+00
		SBL 1229+00 - 1235+00
		NBL 1189+00 - 1201+00
	NBL 1039+00 - 1047+00	SBL 1001+00 - 1008+00

TABLE CI, CONT.

TYPE OF MAINTENANCE	MAINTENANCE SECTION (STATIONS)	CONTROL SECTION (STATIONS)
Underseal and Overlay	SBL 1151+00 - 1161+00	(See Note)**
	SBL 1161+00 - 1171+00	(See Note)**
	NBL 1082+00 - 1092+00	NBL 1008+00 - 1019+00
	NBL 1092+00 - 1101+00	NBL 1008+00 - 1019+00
	NBL 1143+00 - 1148+00	SBL 1171+00 - 1181+00
		SBL 1229+00 - 1235+00
		NBL 1189+00 - 1201+00
Underseal	SBL 1059+00 - 1062+00	SBL 1033+00 - 1036+00
	SBL 1062+00 - 1070+00	NBL 1008+00 - 1019+00
	SBL 1080+00 - 1090+00	SBL 1090+00 - 1100+00
		SBL 1100+00 - 1110+00
		SBL 1110+00 - 1115+00
		SBL 1115+00 - 1127+00
		SBL 1127+00 - 1131+00
		SBL 1131+00 - 1141+00
		NBL 999+00 - 1008+00
		NBL 1072+00 - 1082+00
	NBL 1167+00 - 1172+00	SBL 1181+00 - 1190+00
		NBL 1172+00 - 1176+00

TABLE CI, CONT.

TYPE OF MAINTENANCE	MAINTENANCE SECTION (STATIONS)	CONTROL SECTION (STATIONS)
Subdrains	NBL 1047+00 - 1054+00	NBL 1008+00 - 1019+00
	NBL 1054+00 - 1063+00	(See Note)**
	NBL 1063+00 - 1065+00	SBL 1171+00 - 1181+00
		SBL 1229+00 - 1235+00
		NBL 1189+00 - 1201+00
	NBL 1161+00 - 1165+00	SBL 1204+00 - 1209+00
		NBL 990+00 - 994+00
		NBL 994+00 - 999+00
		NBL 1201+00 - 1209+00
	NBL 1165+00 - 1167+00	SBL 995+00 - 996+00
		SBL 1224+00 - 1229+00
		NBL 1176+00 - 1189+00
Overlay	NBL 1101+00 - 1108+00	SBL 995+00 - 996+00
		SBL 1224+00 - 1229+00
		NBL 1176+00 - 1189+00
	NBL 1108+00 - 1118+00	(See Note)**
	NBL 1118+00 - 1131+00	SBL 1171+00 - 1181+00
		SBL 1229+00 - 1235+00
		NBL 1189+00 - 1201+00

TABLE CI, CONT.

TYPE OF MAINTENANCE	MAINTENANCE SECTION (STATIONS)	CONTROL SECTION (STATIONS)
Overlay	NBL 1131+00 - 1138+00	SBL 995+00 - 996+00
		SBL 1224+00 - 1229+00
		NBL 1176+00 - 1189+00
	NBL 1148+00 - 1152+00	SBL 1001+00 - 1008+00
	NBL 1212+00 - 1225+00	SBL 1204+00 - 1209+00
		NBL 990+00 - 994+00
		NBL 994+00 - 999+00
		NBL 1201+00 - 1209+00
	NBL 1225+00 - 1235+00	(See Note)**
Underseal and Overlay	SBL 1036+00 - 1042+00	NBL 1008+00 - 1019+00
	SBL 1042+00 - 1050+00	NBL 1008+00 - 1019+00
	SBL 1141+00 - 1151+00	SBL 1090+00 - 1100+00
		SBL 1100+00 - 1110+00
		SBL 1110+00 - 1115+00
		SBL 1115+00 - 1127+00
		SBL 1127+00 - 1131+00
		SBL 1131+00 - 1141+00
		NBL 999+00 - 1008+00
		NBL 1072+00 - 1082+00

TABLE C I , CONT.

TYPE OF MAINTENANCE	MAINTENANCE SECTION (STATIONS)	CONTROL SECTION (STATIONS)
Subdrains & Overlay	NBL 1138+00 - 1143+00	SBL 1001+00 - 1008+00
Bituminous Patching	SBL 1196+00 - 1204+00	SBL 1001+00 - 1008+00

* NOTE THAT ALL SECTIONS WITH IDENTICAL ORIGINAL RATINGS ARE COMPARED ON TABLES BI THRU BII.

** NO CONTROL SECTIONS ARE AVAILABLE DUE TO EITHER LENGTH RESTRICTIONS OR EXTENSIONS OF MAINTENANCE SECTIONS. (SEE TEXT.)

APPENDIX D

COST DATA

COSTS OF EACH MAINTENANCE SECTION

The following Tables D1 thru D25 show the costs of each maintenance section labeled "A" to "HH" as shown in Figure 6. They have been calculated using the actual quantities wherever possible and quantity estimates if the actual quantities are unknown. Only the costs of maintenance done during this project were included, omitting the costs of patching done between Fall 1974 and the start of construction.

Section "Z" at NBL 1138-1143 was originally planned to have a concrete shoulder, undersealing, an overlay, and subdrains. However, it was determined that the use of both a concrete shoulder and an overlay was impractical and the concrete shoulder was omitted. Also, it was decided that the need for undersealing was no longer present and it was omitted in that section, leaving only an overlay and subdrains as maintenance in section "Z".

The following sections have no maintenance and consequently no costs:

Section	Stations	
"A"	SBL 990+00	SBL 995+00
"C"	SBL 996+00	SBL 1001+00
"O"	SBL 1204+00	SBL 1209+00
"R"	NBL 990+00	NBL 994+00
"CC"	NBL 1152+00	NBL 1161+00
"FF"	NBL 1172+00	NBL 1176+00

The following sections were patched in Spring 1975 but not in Summer 1975:

"G"	SBL 1033+05	SBL 1036+00
"W"	NBL 1072+05	NBL 1082+00

Section "U" is a special exception and has been omitted.

TABLE D1. COST OF SECTION "B" SBL 995 + 00 → SBL 996 + 00
CONCRETE PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST TOTAL	COST PER 100'
003	Concrete for Patching	31.9 sys	$98.00/sys	100	$3,126	$3,126
002	French Drains for Patch	2	$180.00 ea	100	$ 360	$ 360

COST OF SECTION "B" = $ 3,486 or $ 3,486 / 100'

TABLE D2. COST OF SECTION "D" SBL 1001 + 00 → SBL 1008 + 00
CONCRETE PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
003	Concrete for Patching	126.5 sys	$98.00/sys	700	$12,397	$1,771
002	French Drains for Patch	8	$180.00 ea	700	$ 1,440	$ 206

COST OF SECTION "D" = $ 13,837 or $ 1,977/100'

TABLE D3. COST OF SECTION "E" SBL 1008 + 00 → SBL 1018 + 50
CONCRETE SHOULDER & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
015	Concrete for Shoulder	1283 sys	$ 12.50/sys	1050	$16,038	$1,527
003	Concrete for Patching	100 sys	$ 98.00/sys	1050	$ 9,800	$ 933
002	French Drains for Patch	0	$130.00 ea	1050	0	0

COST OF SECTION "E" = $ 25,838 or $ 2,460 / 100'

TABLE D4. COST OF SECTION "F" SBL 1018 + 50 → SBL 1033 + 05 CONCRETE SHOULDER, SUBDRAINS AND PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
030	6" Pipe for Subdrains	1455 lft	$ 1.50/lft	1455	$ 2,183	$ 150
031	6" Pipe for Outlets	95 lft	$ 4.50/lft	1455	$ 428	$ 29
032	Aggregate for Subdrains	210 cys	$ 9.70/cys	1455	$ 2,037	$ 140
029	Delineator Post	3	$ 15.00 ea	1455	$ 45	$ 3
015	Concrete for Shoulder	1778 sys	$ 12.50/sys	1455	$22,225	$1,527
003	Concrete for Patching	113 sys	$ 98.00/sys	1455	$11,074	$ 761
002	French Drains for Patch	0	$180.00 ea	1455	0	0

COST OF SECTION "F" = $ 37,992 or $ 2,610 / 100'

TABLE D5. COST OF SECTION "H" SBL 1036 + 00 → SBL 1050 + 00
UNDERSEAL, OVERLAY, & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
013	Drilled Holes for Underseal	6	$ 3.00 ea	1400	$ 18	$ 1
014	Underseal Material	0.37 tons	$175.00/tn	1400	$ 65	$ 5
005	Type 0 Compacted Aggregate	50.5 tons	$ 11.00/tn	1400	$ 556	$ 40
006	Type IV Emulsion Surface	130.6 tons	$ 22.00/tn	1400	$ 2,874	$ 205
007	Bituminous Base	691.6 tons	$ 14.75/tn	1400	$10,201	$ 729
008	Bituminous Base No. 53B	355.0 tons	$ 15.00/tn	1400	$ 5,325	$ 380
009	Seal Coat	4.80 tons	$150.00/tn	1400	$ 720	$ 51
010	Prime Coat	0.51 tons	$175.00/tn	1400	$ 89	$ 6
011	Tack Coat	1.33 tons	$150.00/tn	1400	$ 200	$ 14
012	Cover Aggregate	48.3 tons	$ 13.00/tn	1400	$ 628	$ 45
003	Concrete for Patching	22.2 sys	$ 98.00/sys	1400	$ 2,176	$ 155
002	French Drains for Patch	1	$180.00 ea	1400	$ 180	$ 13

COST OF SECTION "H" = $ 23,032 or $ 1,644 / 100'

TABLE D6. COST OF SECTION "I" SBL 1050 + 00 → SBL 1059 + 00
SUBDRAINS & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
030	6" Pipe for Subdrains	900 lft	$ 1.50/lft	900	$1,350	$ 150
031	6" Pipe for Outlets	76 lft	$ 4.50/lft	900	$ 342	$ 38
032	Aggregate for Subdrains	133.6 cys	$ 9.70/cys	900	$1,296	$ 144
029	Delineator Post	2	$ 15.00 ea	900	$ 30	$ 3
003	Concrete for Patching	10.3 sys	$ 98.00/sys	900	$1,009	$ 112
002	French Drains for Patch	0	$180.00 ea	900	$ 0	$ 0

COST OF SECTION "I" = $ 4,027 or $ 447 / 100'

TABLE D7. COST OF SECTION "J" SBL 1059 + 00 → SBL 1090 + 00
UNDERSEAL & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
013	Drilled Holes for Underseal	154	$ 3.00 ea	3100	$ 462	$ 15
014	Underseal Material	9.57 tons	$175.00/ton	3100	$1,675	$ 54
003	Concrete for Patching	39.8 sys	$ 98.00/sys	3100	$3,900	$ 126
002	French Drains for Patch	4	$180.00 ea	3100	$ 720	$ 23

COST OF SECTION "J" = $ 6,757 or $ 218/100'

TABLE D8. COST OF SECTION "K" SBL 1090 + 00 → SBL 1141 + 00
CONCRETE PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
003	Concrete for Patching	151.9 sys	$ 98.00/sys	5100	$14,886	$ 292
002	French Drains for Patch	10	$180.00 ea	5100	$ 1,800	$ 35

COST OF SECTION "K" = $ 16,686 or $ 327/100'

TABLE D9. COST OF SECTION "L" SBL 1141 + 00 → SBL 1171 + 00
UNDERSEAL, OVERLAY, & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
013	Drilled Holes for Underseal	302	$ 3.00 ea	3000	$ 906	$ 30
014	Underseal Material	18.76 tons	$175.00/ton	3000	$ 3,283	$ 109
005	Type O Compacted Aggregate	108.3 tons	$ 11.00/ton	3000	$ 1,191	$ 40
006	Type IV Emulsion Surface	279.9 tons	$ 22.00/ton	3000	$ 6,158	$ 205
007	Bituminous Base	1482 tons	$ 14.75/ton	3000	$21,860	$ 729
008	Bituminous Base No. 53B	760 tons	$ 15.00/ton	3000	$11,400	$ 380
009	Seal Coat	10.29 tons	$150.00/ton	3000	$ 1,544	$ 51
010	Prime Coat	1.10 tons	$175.00/ton	3000	$ 193	$ 6
011	Tack Coat	2.85 tons	$150.00/ton	3000	$ 428	$ 14
012	Cover Aggregate	103.6 tons	$ 13.00/ton	3000	$ 1,347	$ 45
003	Concrete for Patching	35.5 sys	$ 98.00/sys	3000	$ 3,479	$ 116
002	French Drains for Patch	2	$180.00 ea	3000	$ 360	$ 12

COST OF SECTION "L" = $ 52,149 or $ 1,737 / 100'

TABLE D10. COST OF SECTION "M" SBL 1171 + 00 → SBL 1196 + 00

CONCRETE PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
003	Concrete for Patching	47.1 sys	$ 98.00/sys	2500	$ 4,616	$ 185
002	French Drains for Patch	4	$180.00 ea	2500	$ 720	$ 29

COST OF SECTION "M" = $ 5,336 or $ 214 / 100'

TABLE DII. COST OF SECTION "N" SBL 1196 + 00 → SBL 1204 + 00

FULL DEPTH
BITUMINOUS PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
004	Bituminous Patching Material	68.4 sys	$107.00/sys	800	$ 7,319	$ 915
002	French Drains for Patch	0	$180.00 ea	800	$ 0	$ 0

COST OF SECTION "N" = $ 7,319 or $ 915 / 100'

TABLE D12. COST OF SECTION "P" SBL 1212 + 15 → SBL 1224 + 00
CONCRETE SHOULDER & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
015	Concrete for Shoulder	1448 sys	$ 12.50/sys	1185	$18,100	$1,527
003	Concrete for Patching	136.5 sys	$ 98.00/sys	1185	$13,377	$1,129
002	French Drains for Patch	0	$180.00 ea	1185	$ 0	$ 0

COST OF SECTION "P" = $ 31,477 or $ 2,656 / 100'

TABLE D13. COST OF SECTION "Q" SBL 1224 + 00 → SBL 1235 + 00
CONCRETE PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
003	Concrete for Patching	120.5 sys	$ 98.00/sys	1100	$11,809	$1,074
002	French Drains for Patch	0	$180.00 ea	1100	$ 0	$ 0

COST OF SECTION "Q" = $ 11,809 or $ 1,074 / 100

TABLE D14. COST OF SECTION "S" NBL 994 + 00 → NBL 1025 + 00
CONCRETE PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
003	Concrete for Patching	132.5 sys	$ 98.00/sys	3100	$12,985	$ 419
002	French Drains for Patch	5	$180.00 ea	3100	$ 900	$ 29

COST OF SECTION "S" = $ 13,885 or $ 448 / 100'

TABLE D15. COST OF SECTION "T" NBL 1025 + 00 → NBL 1065 + 00
SUBDRAINS & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
030	6" Pipe for Subdrains	4000 lft	$ 1.50/lft	4000	$6,000	$ 150
031	6" Pipe for Outlets	230 lft	$ 4.50/lft	4000	$1,035	$ 26
032	Aggregate for Subdrains	517.1 cys	$ 9.70/cys	4000	$5,016	$ 125
029	Delineator Post	6	$ 15.00 ea	4000	$ 90	$ 2
003	Concrete for Patching	82.3 sys	$ 98.00/sys	4000	$8,065	$ 202
002	French Drains for Patch	0	$180.00 ea	4000	$ 0	$ 0

COST OF SECTION "T" = $ 20,206 or $ 505 / 100'

TABLE D16. COST OF SECTION "V" NBL 1066 + 00 ⟶ NBL 1072 + 05
CONCRETE SHOULDER & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
015	Concrete for Shoulder	739.4 sys	$ 12.50/sys	605	$9,243	$1,528
003	Concrete for Patching	16.7 sys	$ 98.00/sys	605	$1,637	$ 271
002	French Drains for Patch	0	$180.00 ea	605	$ 0	$ 0

COST OF SECTION "V" = $ 10,880 or $ 1,798 / 100'

TABLE D17. COST OF SECTION "X" NBL 1082 + 00 → NBL 1101 + 00
UNDERSEAL, OVERLAY & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
013	Drilled Holes for Underseal	37	$ 3.00 ea	1900	$ 111	$ 6
014	Underseal Material	0.44 tons	$175.00/ton	1900	$ 77	$ 4
005	Type 0 Compacted Aggregate	68.6 tons	$ 11.00/ton	1900	$ 755	$ 40
006	Type IV Emulsion Surface	177.3 tons	$ 22.00/ton	1900	$3,901	$ 205
007	Bituminous Base	558.6 tons	$ 14.75/ton	1900	$8,239	$ 434
008	Bituminous Base No. 53B	260 tons	$ 15.00/ton	1900	$3,900	$ 205
009	Seal Coat	6.52 tons	$150.00/ton	1900	$ 978	$ 51
010	Prime Coat	0.69 tons	$175.00/ton	1900	$ 121	$ 6
011	Tack Coat	1.81 tons	$150.00/ton	1900	$ 272	$ 14
012	Cover Aggregate	65.6 tons	$ 13.00/ton	1900	$ 853	$ 45
003	Concrete for Patching	32.4 sys	$ 98.00/sys	1900	$3,175	$ 167
002	French Drains for Patch	3	$180.00 ea	1900	$ 540	$ 28

COST OF SECTION "X" = $ 22,922 or $ 1,205/100'

TABLE D18. COST OF SECTION "Y" NBL 1101 + 00 → NBL 1138 + 05
OVERLAY & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
005	Type O Compacted Aggregate	133.8 tons	$ 11.00/ton	3705	$ 1,472	$ 40
006	Type IV Emulsion Surface	345.7 tons	$ 22.00/ton	3705	$ 7,605	$ 205
007	Bituminous Base	1890.3 tons	$ 14.75/ton	3705	$27,882	$ 753
008	Bituminous Base No. 53B	1079 tons	$ 15.00/ton	3705	$16,185	$ 437
009	Seal Coat	12.71 tons	$150.00/ton	3705	$ 1,907	$ 51
010	Prime Coat	1.35 tons	$175.00/ton	3705	$ 236	$ 6
011	Tack Coat	3.52 tons	$150.00/ton	3705	$ 528	$ 14
012	Cover Aggregate	127.9 tons	$ 13.00/ton	3705	$ 1,663	$ 45
003	Concrete for Patching	11.1 sys	$ 98.00/sys	3705	$ 1,088	$ 29
004	Bituminous Patching Material	10.3 sys	$107.00/sys	3705	$ 1,102	$ 30
002	French Drains for Patch	2	$180.00 ea	3705	$ 360	$ 10

COST OF SECTION "Y" = $ 60,028 or $ 1,620/100'

TABLE D19. COST OF SECTION "Z" NBL 1138 + 05 → NBL 1143 + 00
OVERLAY, SUBDRAINS, & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
005	Type O Compacted Aggregate	17.9 tons	$ 11.00/ton	495	$ 197	$ 40
006	Type IV Emulsion Surface	46.2 tons	$ 22.00/ton	495	$1,016	$ 205
007	Bituminous Base	244.5 tons	$ 14.75/ton	495	$3,606	$ 729
008	Bituminous Base No. 53B	126 tons	$ 15.00/ton	495	$1,890	$ 382
009	Seal Coat	1.70 tons	$150.00/ton	495	$ 255	$ 52
010	Prime Coat	0.18 tons	$175.00/ton	495	$ 32	$ 6
011	Tack Coat	0.47 tons	$150.00/ton	495	$ 71	$ 14
012	Cover Aggregate	17.1 tons	$ 13.00/ton	495	$ 222	$ 45
030	6" Pipe for Subdrains	495 lft	$ 1.50/lft	495	$ 743	$ 150
031	6" Pipe for Outlets	40 lft	$ 4.50/lft	495	$ 180	$ 36
032	Aggregate for Subdrains	54.4 cys	$ 9.70/cys	495	$ 528	$ 107
029	Delineator Post	1	$ 15.00 ea	495	$ 15	$ 3
003	Concrete for Patching	20.7 sys	$ 98.00/sys	495	$2,029	$ 410
002	French Drains for Patch	0	$180.00 ea	495	$ 0	$ 0

COST OF SECTION "Z" = $ 10,784 or $ 2,179 / 100'

TABLE D20. COST OF SECTION "AA" NBL 1143 + 00 → NBL 1148 + 00

UNDERSEAL, OVERLAY, & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
013	Drilled Holes for Underseal	4	$ 3.00 ea	500	$ 12	$ 2
014	Underseal Material	0.05 tons	$175.00/ton	500	$ 9	$ 2
005	Type 0 Compacted Aggregate	18.1 tons	$ 11.00/ton	500	$ 199	$ 40
006	Type IV Emulsion Surface	46.7 tons	$ 22.00/ton	500	$1,027	$ 205
007	Bituminous Base	247.0 tons	$ 14.75/ton	500	$3,643	$ 729
008	Bituminous Base No. 53B	127.0 tons	$ 15.00/ton	500	$1,905	$ 381
009	Seal Coat	1.72 tons	$150.00/ton	500	$ 258	$ 52
010	Prime Coat	0.18 tons	$175.00/ton	500	$ 32	$ 6
011	Tack Coat	0.48 tons	$150.00/ton	500	$ 72	$ 14
012	Cover Aggregate	17.3 tons	$ 13.00/ton	500	$ 225	$ 45
003	Concrete for Patching	0	$ 98.00/sys	500	$ 0	$ 0
002	French Drains for Patch	0	$180.00 ea	500	$ 0	$ 0

COST OF SECTION "AA" = $ 7,382 or $ 1,476/100'

TABLE D21. COST OF SECTION "BB" NBL 1148 + 00 → NBL 1152 + 00
OVERLAY & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
005	Type O Compacted Aggregate	14.4 tons	$ 11.00/ton	400	$ 158	$ 40
006	Type IV Emulsion Surface	37.3 tons	$ 22.00/ton	400	$ 821	$ 205
007	Bituminous Base	197.6 tons	$ 14.75/ton	400	$2,915	$ 729
008	Bituminous Base No. 53B	102.0 tons	$ 15.00/ton	400	$1,530	$ 383
009	Seal Coat	1.37 tons	$150.00/ton	400	$ 206	$ 51
010	Prime Coat	0.15 tons	$175.00/ton	400	$ 26	$ 7
011	Tack Coat	0.38 tons	$150.00/ton	400	$ 57	$ 14
012	Cover Aggregate	13.8 tons	$ 13.00/ton	400	$ 179	$ 45
003	Concrete for Patching	10.2 sys	$ 98.00/sys	400	$1,000	$ 250
002	French Drains for Patch	1	$180.00 ea	400	$ 180	$ 45

COST OF SECTION "BB" = $ 7,072 or $ 1,769 / 100'

TABLE D22. COST OF SECTION "DD" NBL 1161 + 00 → NBL 1167 + 00
SUBDRAINS & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
030	6" Pipe for Subdrains	600 lft	$ 1.50/lft	600	$ 900	$ 150
031	6" Pipe for Outlets	40 lft	$ 4.50/lft	600	$ 180	$ 30
032	Aggregate for Subdrains	97.4 cys	$ 9.70/cys	600	$ 945	$ 157
029	Delineator Post	1	$ 15.00 ea	600	$ 15	$ 3
003	Concrete for Patching	0	$ 98.00/sys	600	$ 0	$ 0
002	French Drains for Patch	0	$180.00 ea	600	$ 0	$ 0

COST OF SECTION "DD" = $ 2,040 or $ 340/100'

TABLE D23. COST OF SECTION "EE" NBL 1167 + 00 → NBL 1172 + 00
UNDERSEAL (NO PATCHING)

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
013	Drilled Holes for Underseal	61	$ 3.00 ea	500	$ 183	$ 37
014	Underseal Material	0.73 tons	$175.00/tn	500	$ 128	$ 26

COST OF SECTION "EE" = $ 311 or $ 63/100'

TABLE D24. COST OF SECTION "GG" NBL 1176 + 00 → NBL 1209 + 00
CONCRETE PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
003	Concrete for Patching	162.6 sys	$ 98.00/sys	3300	$15,935	$ 483
002	French Drains for Patch	4	$180.00 ea	3300	$ 720	$ 22

COST OF SECTION "GG" = $ 16,655 or $ 505 / 100'

TABLE D25. COST OF SECTION "HH" NBL 1212 + 00 → NBL 1235 + 00
OVERLAY & PATCHING

ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	SECTION LENGTH	COST	
					TOTAL	PER 100'
005	Type 0 Compacted Aggregate	83.0 tons	$ 11.00/ton	2300	$ 913	$ 40
006	Type IV Emulsion Surface	372.0 tons	$ 22.00/ton	2300	$ 8,184	$ 356
007	Bituminous Base	1967.3 tons	$ 14.75/ton	2300	$29,018	$1,262
008	Bituminous Base No. 53B	483.0 tons	$ 15.00/ton	2300	$ 7,245	$ 315
009	Seal Coat	7.89 tons	$150.00/ton	2300	$ 1,184	$ 51
010	Prime Coat	0.84 tons	$175.00/ton	2300	$ 147	$ 6
011	Tack Coat	2.19 tons	$150.00/ton	2300	$ 329	$ 14
012	Cover Aggregate	79.4 tons	$ 13.00/ton	2300	$ 1,032	$ 45
003	Concrete for Patching	49.2 sys	$ 98.00/sys	2300	$ 4,822	$ 210
002	French Drains for Patch	0	$180.00 ea	2300	$ 0	$ 0

COST OF SECTION "HH" = $ 52,874 or $ 2,299 / 100'

Comparison of Costs of 100' of the Various Maintenance Methods

The following table compares the cost of 100' of the various types of maintenance excluding any patching costs in the sections. Subdrain costs are computed at both the actual 4' depth and the 2' depth that could be used.

TABLE D26. COMPARISON OF COSTS OF DIFFERENT MAINTENANCE TYPES EXCLUSIVE OF PATCHING

(COSTS ARE DOLLARS PER 100 ft. OF TWO-LANE PAVEMENT)

TYPE OF MAINTENANCE	ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	COST PER 100'
CONC. SHOULDER	015	CONCRETE FOR SHOULDER	122.2 SYS.	$12.50/SYS.	1,527
				TOTAL COST	$1,527
SUBDRAINS (4' DEEP)	030	6" PIPE FOR SUBDRAINS	100 LFT.	$1.50/LFT	150
	031	6" PIPE FOR OUTLETS	8 LFT.	$4.50/LFT	36
	032	AGGREGATE FOR SUBDRAINS	17.3 CYS	$9.70/CYS	168
	029	DELINEATOR POST	.2	$15.00 EA	3
				TOTAL COST	$357
SUBDRAINS (2' DEEP)	030	6" PIPE FOR SUBDRAINS	100 LFT.	$1.50/LFT	150
	031	6" PIPE FOR OUTLETS	8 LFT.	$4.50/LFT	36
	032	AGGREGATE FOR SUBDRAINS	8.65 CYS	$9.70/CYS	84
	029	DELINEATOR POST	.2	$15.00 EA	3
				TOTAL COST	$273
UNDERSEAL	013	DRILLED HOLES FOR UNDERSEAL	12	$3.00 EA	36
1 ROW 8 C-C 0.06212 TON/HOLE	014	UNDERSEAL MATERIAL	.7454 TON	$175.00/TON	130
				TOTAL COST	$166

TABLE D26, CONTINUED

(COSTS ARE DOLLARS PER 100 ft. OF TWO-LANE PAVEMENT)

TYPE OF MAINTENANCE	ITEM NO.	DESCRIPTION	QUANTITY	UNIT PRICE	COST PER 100'
OVERLAY 2 LANES 3" THICK	005	TYPE O COMPACTED AGGREGATE	3.61 TONS	$11.00/TON	40
	006	TYPE IV EMULSION SURFACE	9.33 TONS	$22.00/TON	205
	007	BITUMINOUS BASE	49.4 TONS	$14.75/TON	729
	008	BITUMINOUS BASE 53 B	25.4 TONS	$15.00/TON	381
	009	SEAL COAT	.343 TONS	$150.00/TON	51
	010	PRIME COAT	.0365 TONS	$175.00/TON	6
	011	TACK COAT	.095 TONS	$150.00/TON	14
	012	COVER AGGREGATE	3.453 TONS	$13.00/TON	45
				TOTAL COST	$1,471

APPENDIX E

RECORD OF UNDERSEALING

TABLE E I. RECORD OF UNDERSEALING ON SOUTH BOUND LANE

STATION		CATEGORY	ROWS	NO. OF HOLES
FROM	TO			
1171+00	1170+50	2	1	6
1170+50	1170+40	5	2	5
1170+40	1169+25	2	1	13
1169+25	1168+00	3	2	29
1168+00	1167+45	2	1	6
1167+45	1167+35	5	2	3
1167+35	1166+55	2	1	9
1166+55	1166+45	5	2	1
1166+45	1162+35	1c	1	52
1162+35	1162+10	3	2	7
1162+10	1161+50	1c	1	7
1161+50	1160+65	2	1	11
1160+65	1160+00	3	2	17
1160+00	1158+00	1	0	0
1158+00	1157+75	2	1	4
1157+75	1157+65	3	2	3
1157+65	1155+50	2	1	27
1155+50	1154+50	1	0	0
1154+50	1154+00	3	2	11
1154+00	1153+85	6	2	4
1153+75	1153+00	3	2	21
1153+00	1151+75	1	0	0
1151+75	1151+25	3	2	17
1151+25	1149+00	1	0	0
1149+00	1148+00	2	1	14
1148+00	1146+80	1	0	0
1146+80	1146+70	6	2	4
1146+70	1143+00	1	0	0

TABLE E I, CONTINUED

STATION		CATEGORY	ROWS	NO. OF HOLES
FROM	TO			
1143+00	1141+75	3	2	31
1141+75	1141+00	1	0	0
			Total	= 302
1090+00	1088+00	1c	1	25
1088+00	1087+25	5	1	9
1087+25	1085+75	1c	1	18
1085+75	1085+00	5 & 6	1	9
1085+00	1083+50	1c	1	18
1083+50	1083+00	5	1	6
1083+00	1081+00	1c	1	25
1081+00	1080+00	5	1	12
1080+00	1075+50	1	0	0
1075+50	1074+50	5	1	12
1074+50	1069+30	1	0	0
1069+30	1069+10	6	1	2
1069+10	1064+50	1	0	0
1064+50	1063+00	3	1	18
1063+00	1059+00	1	0	0
			Total	= 154
1050+00	1047+60	1	0	0
1047+60	1047+40	6	1	2
1047+40	1042+30	1	0	0
1042+30	1042+10	6	1	2
1042+10	1036+75	1	0	0
1036+75	1036+45	6	1	2
1036+45	1036+00	1	0	0
			Total	= 6

TABLE E2. RECORD OF UNDERSEALING ON NORTH BOUND LANE

STATION		CATEGORY	ROWS	NO. OF HOLES
FROM	TO			
1082+00	1082+65	1	0	0
1082+65	1082+85	6	1	2
1082+85	1084+50	1	0	0
1084+50	1085+00	2	1	7
1085+00	1085+25	3	0	0
1085+25	1086+00	2	1	8
1086+00	1086+20	6	1	2
1086+20	1086+90	1	0	0
1086+90	1087+00	6	1	2
1087+00	1088+00	1	0	0
1088+00	1088+40	2	1	6
1088+40	1088+75	3	0	0
1088+75	1089+00	2	1	4
1089+00	1091+65	1	0	0
1091+65	1091+85	6	1	2
1091+85	1094+35	1	0	0
1094+35	1094+65	6	1	2
1094+65	1096+95	1	0	0
1096+95	1097+25	6	1	2
1097+25	1101+00	1	0	0
			Total =	37
1138+05	1145+00	1	0	0
1145+00	1145+25	6	1	2
1145+25	1146+65	1	0	0
1146+65	1146+80	6	1	2
1146+80	1148+00	1	0	0
			Total =	4

TABLE E2, CONTINUED

STATION		CATEGORY	ROWS	NO. OF HOLES
FROM	TO			
1167+00	1167+75	1c	1	10
1167+75	1169+25	3	1	18
1169+25	1170+50	1c	1	15
1170+50	1171+50	3	1	12
1171+50	1172+00	1c	1	6
			Total =	61

APPENDIX F

RECORD OF CONCRETE PATCHING

TABLE F I. RECORD OF PATCHES POURED DURING PROJECT
(CONCRETE UNLESS INDICATED OTHERWISE)

LANE	STATION	AREA * IN SQ. FT.	PICTURE NUMBER	TYPE OF MAINTENANCE USED
SBL-RT	1235+00	(21.0+19.5)½(12)=243.0		Concrete Patching Only
SBL-RT	1232+45	(16.0+9.1)½(12)= 150.6		Concrete Patching Only
SBL-RT	1230+55	(3.5+3.3)½(12) = 40.8		Concrete Patching Only
SBL-RT	1229+90	(8.8+8.0)½(12) = 100.8		Concrete Patching Only
SBL-RT	1226+85	(18.3+18.1)½(12)=218.4		Concrete Patching Only
SBL-Center	1226+85	(27.1+28.1)½(12)=331.2		Concrete Patching Only
SBL-RT	1220+60	(18.5+19.2)½(12)=226.2		Concrete Shoulder
SBL-RT	1220+45	(4.1+4.9)½(12) = 54.0		Concrete Shoulder
SBL-RT	1220+00	(5.5+6.4)½(12) = 71.4		Concrete Shoulder
SBL-Center	1220+00	(4.4+5.2)½(12) = 57.6		Concrete Shoulder
SBL-RT	1219+65	(6.7+6.1)½(12) = 76.8		Concrete Shoulder
SBL-RT	1218+20	(18.8+22.3)½(12)=246.6		Concrete Shoulder
SBL-RT	1217+80	(9.3+7.1)½(12) = 98.4		Concrete Shoulder
SBL-RT	1216+95	(4.2+5.6)½(12) = 58.8		Concrete Shoulder
SBL-RT	1215+35	(28.2)(12) = 338.4		Concrete Shoulder
SBL-RT	1200+30	(36.6+36.2)½(12)=436.8	1c9&10	Full Depth Bituminous Patching
SBL-RT	1197+15	(14.0+15.8)½(12)=178.8	1c11&2c5	Full Depth Bituminous Patching
SBL-RT	1193+25	(4.5+3.7)½(12) = 49.2	2c6	Concrete Patching Only

TABLE F1, CONTINUED

LANE	STATION	AREA * IN SQ. FT.	PICTURE NUMBER	TYPE OF MAINTENANCE USED
SBL-RT	1186+75	(9.1+7.9)½(12) =102.0	2c7	Concrete Patching Only
SBL-RT	1184+25	(5.7+5.6)½(12) = 67.8	2c8	Concrete Patching Only
SBL-RT	1180+75	(7.6+6.0)½(12) = 81.6	2c9	Concrete Patching Only
SBL-RT	1175+75	(10.8+9.8)½(12) =123.6	2c10	Concrete Patching Only
SBL-LT	1165+77	(3.5+3.6)½(12) = 42.6	2c11	Underseal and Overlay
SBL-RT	1153+95	(14.0+14.4)½(12)=170.4	2c12	Underseal and Overlay
SBL-RT	1146+75	(8.3+9.5)½(12)= 106.8	4c3	Underseal and Overlay
SBL-RT	1131+50	(15.6+17.5)½(12)=198.6	4c4	Concrete Patching Only
SBL-RT	1129+70	(15.8)(12) = 189.6	4c5	Concrete Patching Only
SBL-RT	1128+95	(7.3)(12) = 87.6	4c6	Concrete Patching Only
SBL-RT	1121+55	(1.9)(12) = 22.8	4c7	Concrete Patching Only
SBL-RT	1121+45	(8.3+12.3)½(12)= 123.6	4c8	Concrete Patching Only
SBL-RT	1119+53	(7.0+9.2)½(12) = 97.2	4c9	Concrete Patching Only
SBL-RT	1115+53	(4.2+5.9)½(12) = 60.6	4c10	Concrete Patching Only
SBL-RT	1111+65	(8.5+10.5)½(12) =114.0	4c11	Concrete Patching Only
SBL-RT	1104+35	(11.6+12.0)½(12)=141.6	4c12	Concrete Patching Only
SBL-RT	1093+45	(27.2+28.1)½(12)=331.8	4c13	Concrete Patching Only
SBL-RT	1088+20	(11.5+13.0)½(12)=147.0	4c14	Underseal

TABLE F1, CONTINUED

LANE	STATION	AREA * IN SQ. FT.	PICTURE NUMBER	TYPE OF MAINTENANCE USED
SBL-RT	1085+60	(8.5+8.7)½(12) = 103.2	5b9	Underseal
SBL-RT	1085+25	(4.5+4.1)½(12) = 51.6	5b10	Underseal
SBL-RT	1069+20	(4.9+4.5)½(12) = 56.4	5b11	Underseal
SBL-LT	1052+80	(7.7+7.8)½(12) = 93.0	6c1	Subdrains
SBL-LT	1047+50	(13.0+11.3)½(12)= 145.8	6c3	Underseal and Overlay
SBL-RT	1042+25	(5.2+3.8)½(12) = 54.0	6c4	Underseal and Overlay
SBL-RT	1032+80	(5.4+7.0)½(12) = 74.4		Subdrains & Concrete Shoulders
SBL-RT	1029+75	(18.1)(12) = 217.2		Subdrains & Concrete Shoulders
SBL-RT	1028+70	(1.5+3.7)½(12) = 31.2	6c7	Subdrains & Concrete Shoulders
SBL-RT	1027+65	(5.5+7.8)½(12) = 79.8	6c8	Subdrains & Concrete Shoulders
SBL-RT	1024+40	(3.6+3.7)½(12) = 43.8	6c9	Subdrains & Concrete Shoulders
SBL-RT	1019+52	(3.9+4.2)½(12) = 48.6	6c10	Subdrains & Concrete Shoulders
SBL-RT	1019+15	(10.8+12.2)½(12) =138.0	6c11	Subdrains & Concrete Shoulders
SBL-RT	1018+90	(14.2+16.0)½(12) =181.2	6c12	Subdrains & Concrete Shoulders
SBL-LT	1018+90	(16.8)(12) = 201.6		Subdrains & Concrete Shoulders
SBL-RT	1018+20	(28.4+27.9)½(12) =337.8	6c13,14,15	Concrete Shoulder
SBL-RT	1016+90	(11.1 11.6)½(12) =136.2	6c16	Concrete Shoulder
SBL-RT	1014+25	(11.4+12.4)½(12) =142.8	6c17	Concrete Shoulder

TABLE F I, CONTINUED

LANE	STATION	AREA * IN SQ. FT.	PICTURE NUMBER	TYPE OF MAINTENANCE USED
SBL-RT	1013+35	(4.2+4.0)½(12) = 49.2	6c18	Concrete Shoulder
SBL-RT	1012+50	(4.7)(12) = 56.4	6c19	Concrete Shoulder
SBL-RT	1008+30	(15.0+14.6)½(12)=177.6	6c20	Concrete Shoulder
SBL-RT	1007+78	(8.7+8.8)½(12) = 105.0	7c7	Concrete Patching Only
SBL-RT	1007+45	(5.7+4.5)½(12) = 61.2	7c8	Concrete Patching Only
SBL-LT	1007+45	(6.5+6.7)½(12) = 79.2		Concrete Patching Only
SBL-RT	1005+45	(10.1+6.9)½(12)= 102.0	8c11	Concrete Patching Only
SBL-RT	1005+20	(21.1+20.9)½(12)=252.0	8c12&13	Concrete Patching Only
SBL-RT	1004+60	(10.1+10.5)½(12)=123.6	8c14	Concrete Patching Only
SBL-RT	1003+70	(8.7+6.9)½(12) = 93.6	8c15	Concrete Patching Only
SBL-RT	1002+95	(23.2+20.7)½(12)=263.4	8c16	Concrete Patching Only
SBL-RT	1002+45	(5.6+4.1)½(12) = 58.2	8c17	Concrete Patching Only
SBL-RT	996+00	(7.1+6.5)½(12) = 81.6	8c18	Concrete Patching Only
SBL-RT	995+75	(18.3+15.9)½(12)=205.2	8c19	Concrete Patching Only
NBL-RT	996+35	(7.5+6.0)½(12) = 81.0		Concrete Patching Only
NBL-RT	1004+10	(11.2+12.4)½(12)=141.6	14c2	Concrete Patching Only
NBL-RT	1006+25	(2.5+1.9)½(12) = 26.4	14c3	Concrete Patching Only
NBL-LT	1013+90	(59.4+59.7)½(12)=714.6		Concrete Patching Only

TABLE F1, CONTINUED

LANE	STATION	AREA * IN SQ. FT.	PICTURE NUMBER	TYPE OF MAINTENANCE USED
NBL-RT	1014+20	(11.1)(12) = 133.2		Concrete Patching Only
NBL-RT	1021+27	(8.5+7.5)½(12) = 96.0	14c5	Concrete Patching Only
NBL-RT	1028+85	(6.6+7.0)½(12) = 81.6	14c7	Subdrains
NBL-RT	1030+20	(6.5+7.6)½(12) = 84.6	14c8	Subdrains
NBL-RT	1031+05	)10.6+8.9)½(12)= 117.0	14c9	Subdrains
NBL-RT	1033+52	(20.5+20.9)½(12)=248.4	14c10	Subdrains
NBL-RT	1041+60	(13.3+13.0)½(12)=157.8	14c11	Subdrains
NBL-RT	1042+30	(2.4+6.2)½(12) = 51.6	14c12	Subdrains
NBL-RT	1069+25	(12.8+12.3)½(12)=150.6	14c13	Concrete Shoulder
NBL-RT	1082+75	(10.1+9.0)½(12) =114.6	8c4	Underseal and Overlay
NBL-RT	1086+96	(2.9+3.9)½(12) = 40.8	8c5	Underseal and Overlay
NBL-RT	1091+75	(10.7+12.0)½(12)=136.2	8c6	Underseal and Overlay
NBL-LT	1106+35	(6.0+9.4)½(12) = 92.4	8c7	Overlay
NBL-RT	1132+54	(3.9)(12) = 46.8	8c8	Overlay
NBL-RT	1134+50	(4.9+4.0)½(12) = 53.4	8c9	Overlay
NBL-RT	1140+70	(16.8+14.2)½(12)=186.0	8c10	Underseal, Overlay & Subdrains
NBL-RT	1149+50	(7.7+7.6)½(12) = 91.8	10c15&16	Overlay
NBL-RT	1185+50	(8.6+7.9)½(12) = 99.0	10c17	Concrete Patching Only

TABLE F1, CONTINUED

LANE	STATION	AREA * IN SQ. FT.	PICTURE NUMBER	TYPE OF MAINTENANCE USED
NBL-RT	1187+10	(10.5+7.1)½(12) =105.6	10c18	Concrete Patching Only
NBL-RT	1187+75	(7.7+8.5)½(12) = 97.2	10c19	Concrete Patching Only
NBL-RT	1188+95	(8.7+6.7)½(12) = 92.4	10c20	Concrete Patching Only
NBL-RT	1197+95	(37.4+35.3)½(12)=436.2	11b1	Concrete Patching Only
NBL-RT	1200+25	(28.6+27.2)½(12)=334.8	11b2	Concrete Patching Only
NBL-RT	1204+70	(20.7+19.4)½(12)=240.6	11b3	Concrete Patching Only
NBL-RT	1206+50	(4.0+5.6)½(12) = 57.6	11b4	Concrete Patching Only
NBL-RT	1218+45	(12.7+14.1)½(12)=160.8		Overlay
NBL-RT	1221+35	(4.8)(12) = 57.6		Overlay
NBL-RT	1223+45	(2.5)(12) = 30.0		Overlay
NBL-RT	1225+80	(16.2)(12) = 194.4		Overlay

* FROM ISHC FIELD BOOK

APPENDIX G

ABSTRACTS OF APPLICABLE SPECIFICATIONS

APPENDIX G

ABSTRACTS OF APPLICABLE SPECIFICATIONS*

The following abstracts are the specifications for the materials used on this project. All Specification Numbers refer to the Indiana State Highway Commission Standard Specifications dated 1974 unless otherwise noted.

Concrete Shoulders

Plain Concrete Shoulders, as specified for this contract shall be in accordance with all applicable requirements of Section 500, the Typical Sections and Details included in the plans.**

Subdrains

Porous Concrete Pipe***

906.05 Porous Concrete Pipe. This pipe shall conform to the requirements of AASHO M 176 for the specified diameters.

FBC Non-perforated CS Pipe

907.03. Corrugated Steel Pipe for Underdrains. This pipe shall conform to the requirements of AASHO M 36 for Type III (Class IV may only be used in place of 6-inch round pipe), except as follows:

*In some cases, several alternates are presented. At the time of preparation of this report, the item described is understood to have been used. Any exceptions to this will be noted at a later date in future interim reports.

**Special provision.

***Group K pipe for underdrains were required.

(a) Resistance spot welded lap joints will not be permitted.

(b) Sampling for check testing by the State shall be as directed.

(c) Band couplers shall have corrugations that mesh with the corrugations of the pipes.

If the pipe is to be bituminous coated, it shall conform with type A as set out in 907.07.

The sheet manufacturer's certified analysis and guarantee to the Commission, the certified mill report to the fabricator, and the fabricator's certificate will be required as set out in 907.02.

907.07 Bituminous Coated Corrugated Steel or Aluminum Pipe, Pipe-Arch, or Underdrain. This pipe shall conform with the requirements of 907.02 through 907.06 and AASHO M 190, except as modified herein. Coupling bands shall be fully bituminous coated.

Connecting or coupling bands shall be the 2-piece type when used with coated pipe of 36-inch and larger diameter.

The bituminous material for coating shall meet the requirements of AASHO M 190 except samples of the bituminous material shall be taken from the working tank prior to or during coating of the pipe. When applied to the pipe, the bituminous material shall be free from impurities and the metal shall be free from grease, dust, or moisture. Either process set out below may be used for application.

(a) When the pipe is not preheated, the temperature of the asphalt at the time of immersion shall be $400^{\circ}F \pm 5$. The duration of the immersion in the asphalt shall conform with the following:

Thickness (inches)	0.052
Minimum Immersion Time for First Dip (Minutes)	2.0

(b) When the pipe is preheated it shall be brought to a temperature of 300°F and the asphalt shall be heated to a temperature of 380°F ± 5 before the pipe is dipped.

In either process, the pipe shall be dipped a second time (or more if necessary) to give a minimum thickness of 0.05 inches.

Number 7 Gravel for Backfill

See section on Coarse Aggregates in this Appendix for specifications of No. 7 gravel.

Undersealing

Type II Asphalt for Undersealing*

902.06. Asphalt for Undersealing Cement Concrete Pavement. Asphalt to be used for undersealing shall meet the following requirements.

Characteristics	GRADES* I	GRADES* II
Softening Point (Ring and Ball), (°F)	160°-180°F.	180°-200°F.
Penetration of Original Samples:		
At low temperature, 200 g., 60 sec. (in ice water bath not exceeding 40°F)	15+	10+
At 77°F., 100 g., 5 sec.	25-40	15-30
At 115°F., 50 g., 5 sec.	90—	60—
Ductility at 77°F (cms.)	3+	2+
Flash Point (Cleveland Open Cup) (°F)	425+	425+
Solubility in organic solvent (%)	99.0+	99.0+
Loss on Heating, 325°F., 5 hrs. (%)	1.0—	0.5—
Penetration After Loss on Heating (% of original)	70+	70+
General Requirements	The asphalt shall be prepared by the refining of petroleum. It shall be uniform in character and shall not foam when heated to 350°F.	

* Unless otherwise specified, Grade II shall be used.

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*See first footnote on first page of this Appendix.

Asphalt Concrete Overlay

Materials

401.02 Composition of Mixtures. The bituminous plant mix shall be composed of a mixture of aggregate, filler if required, other materials when specified, and bituminous material. The aggregate shall be sized, uniformly graded, and combined in such proportions that the resulting bituminous mixture meets the requirements of the job-mix formula and the composition limits established in 402 or 403. The gradation of the aggregate in the mixture shall not vary from the low limit on one sieve size to the high limit on the adjacent sieve size nor from the high limit on one sieve size to the low limit on the adjacent sieve size.

Type IV Emulsion Surface

402.04

Type of Mixture	Coarse Aggregate Size	Fine Aggregate Size	Per Cent* Passing Sieve		Per Cent of Bitumen**
			#6	#200	
Surface IV		14-2, 17, 18	90-100	0-5	7.0-8.0

* Based on total weight of aggregate.

** Based on total weight of mixture, exclusive of water or solvent.

Additional Requirements. The per cent of bitumen specified in the composition of mixtures above is a percentage of the total weight of mixture exclusive of water or solvent. The amount of moisture remaining in mixtures at the time of discharge from the mixer shall not exceed 0.5% for base and binder mixtures or 0.3% for surface mixtures based on the weight of the test sample after drying.

3. Composition Limits for Surface Mixtures

Sieve Size	Total Per Cent of Aggregates Passing Sieves, Based on Total Weight of Aggregates			
	Coarse Aggregate Size			Fine Aggregate Size
	Type II		Type III	Type IV
	No. 8	No. 9	No. 11	Notes 2 & 3
1 inch	100	-----	-----	-----
¾ inch	92–100	100	-----	-----
½ inch	61–83	82–94	100	-----
⅜ inch	52–72	58–83	83–98	100
No. 4	47–64	47–66	54–74	97–100
No. 8	35–62	35–62	40–69	71–100
No. 16	24–53	24–53	26–57	50–80
No. 30	9–34	9–34	11–37	20–60
No. 50	2–22	2–22	3–23	5–35
No. 100	0–10	0–10	0–10	1–15
No. 200	0–4	0–4	0–4	0–5

Notes: 1. For Types II & III mixtures, the fine aggregate may be either size 14-2 or 17.

2. For Type IV mixtures, the fine aggregate may be either size 14-2, 17, or 18, or a blend of acceptable fine aggregates, including the use of not to exceed 20% manufactured sand (such as limestone or blast furnace slag). In any case, the gradation shall meet the specified composition limits. Windblown sand, "Burr Oak" sand, or similar sands will not be acceptable for blending. The fine aggregates, including those produced by blending, shall conform to the requirements of 903.01(f).

3. Fine aggregates used in Type IV mixtures shall have a minimum Florida bearing value of 30, when tested in accordance with Test Method No. Ind. 201-72, copies of which are on file at the Division of Materials and Tests.

Bituminous Base*

See section on Base Courses of this Appendix.

Number 53B Bituminous Base for Shoulder

See section on Base Courses in this Appendix for specifications of No. 53B Bituminous Base

Type "O" Compacted Aggregate (No. 73)

303.01 Type O. Other than plant-mix. The aggregate shall contain sufficient moisture to avoid segregation during loading, hauling, placing, and shaping operations.

See section on Course Aggregates in this Appendix for specifications of No. 73 Compacted Aggregate.

Type II Seal Coat, Tack Coat, and Prime Coat

407.02 Bituminous Material. The type and grade of bituminous material shall be one of the following, or as specified or directed, and meet referenced requirements.

Bituminous Materials for Seal Coat
  Cut-Back Asphalt, RC-800, RC-3000............. 902.03
  Asphalt Emulsion, RS-2, AE-90, AE-150......... 902.04

Bituminous Material for Prime Coat
  Cut-Back Asphalt, MC-70....................... 902.03
  Asphalt Emulsion, AE-P........................ 902.04
  Tar, RT-1, RT-2............................... 902.02

Bituminous Material for Tack Coat
  Asphalt Emulsion, AE-T........................ 902.04
  Cut-Back, Asphalt, RC-70...................... 902.03

407.03 Cover Aggregate. Cover aggregate shall meet the requirements of 903 for the size specified.

Coarse Aggregates for Sealing (Stone, gravel, slag, boiler slag) class A, No. 8, 9, 11, 12, 13.................................. 903.02

Fine Aggregate for Sealing (natural sand), No. 17, 14-2.............................. 903.01

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*Data on exact type of material will be included in a later report.

SEAL TYPES

Type	Cover Aggregate Size No.	Rate of Application per Square Yard	
		Aggregate Pounds	Bituminous Material Gallon at 60°F.
Type II 1st Application	11	15–20	0.25–0.35
2nd Application	12,13	15–25	0.20–0.30

902.03 Cut-Back Asphalts. Cut-back asphalts shall be composed of an intimate homogeneous mixture of an asphalt base and a suitable distillate designed for rapid, medium, or slow curing. Cut-back asphalts may also contain an additive as an aid in uniformly coating wet, damp, or dry aggregates used in patching mixtures or bituminous pavements. These asphalts shall be substantially free from water, shall not separate when allowed to stand, and shall not foam when heated to permissible temperatures. When an additive is used, it shall be incorporated homogenously in the asphalt at the point of manufacture.

902.03(a)

(a) Requirements for Rapid Curing Asphalts (with and without additive).

Characteristics	Grades			
	RC-70 RCA-70	RC-250 RCA-250	RC-800 RCA-800	RC-3000 RCA-3000
Flash Point (Open Tag.), (°F.)	- -	80+	80+	80+
Furol Viscosity at 122°F. (Sec.)	60–120	-------	-------	-------
Furol Viscosity at 140°F. (Sec.)	-------	125–250	-------	-------
Furol Viscosity at 180°F. (Sec.)	-------	-------	100–200	300–600
Kinematic Viscosity at 140°F. (cs.) (2)	70–140	250–500	800–1600	3000–6000
Distillation—				
Distillate (per cent of total distillate to 680°F.):				
to 374°F.	10+	-------	-------	-------
to 437°F.	50+	35+	15+	-------
to 500°F.	70+	60+	45+	25+
to 600°F.	85+	80+	75+	70+
Residue from distillation to 680°F. (volume per cent by difference)	55+	65+	75+	80+
Tests on Residue from Distillation:				
Penetration, 77°F., 100 g., 5 sec.				
(with additive)	80–160	80-160	80–160	80–160
(without additive)	80–120	80–120	80–120	80–120
Ductility 77°F. (cms.) (1)	100+	100+	100+	100+
Solubility in organic solvents (%) (1)	99.5+	99.5+	99.5+	99.5+
Spot Test (Std. Naphtha) (1)	Neg.	Neg.	Neg.	Neg.

(1) Test may be waived by the Engineer.
(2) Viscosity may be determined by either the Saybolt-Furol or Kinematic test. In case of dispute, the Furol viscosity test shall prevail.

902.03(b)

(b) Requirements for Medium Curing Asphalts (with and without additive).

Characteristics	Grades			
	MC-70 MCA-70	MC-250 MCA-250	MC-800 MCA-800	MC-3000 MCA-3000
Flash Point (Open Tag), °F.*	100+	150+	150+	150+
Furol Viscosity at 122°F., Sec.	60–120	-------	-------	-------
Furol Viscosity at 140°F., Sec.	-------	125–250	-------	-------
Furol Viscosity at 180°F., Sec.	-------	-----	100–200	300–600
Kinematic Viscosity at 140°F., (cs.) (2)	70–140	250–500	800–1600	3000–6000
Distillation—				
Distillate (per cent of total distillate to 680°F.):				
to 437°F.	20–	0–10	-------	-------
to 500°F.	20–60	15–55	35–	15–
to 600°F.	65–90	60–87	45–80	15–75
Residue from distillation to 680°F. (volume per cent by difference)	55+	67+	75+	80+
Tests on Residue from Distillation:				
Penetration 77°F., 100g., 5 sec.				
(without additive)	120–250	120–250	120–250	120–250
(with additive)	120–300	120–300	120–300	120–300
Ductibility, 77°F., (cms.) (1) (3)	100+	100+	100+	100+
Solubility in organic solvents (%)	99.5+	99.5+	99.5+	99.5+
Spot Test (Std. Naphtha) (1)	Neg.	Neg.	Neg.	Neg.

(1) Test may be waived by the Engineer.

(2) Viscosity may be determined by either the Saybolt-Furol or Kinematic test. In case of dispute, the Furol viscosity test shall prevail.

(3) If penetration of residue is more than 200 and its ductility at 77°F. is less than 100, the material will be acceptable if its ductility at 60°F. is 100+.

* Flash point by Cleveland Open Cup may be used for products having a flash point greater than 175°F.

902.04(a)

(a) Requirements for Asphalt Emulsions.

	RS-2 (1), (2)	AE-60 (1)	AE-90 (2)	AE-150 (1), (2)	AE-150-L (9)	AE-300 (1)	AE-T (1), (7)	AE-P
Furol-Viscosity at 77°F. (Sec.)		50+	50+	50+		50+		
at 122°F. (Sec.)	75–300							15–150
The distillate per cent by weight when distilled to 260°C. (500°F.)	32—	32—	32—	33—		32—		35—
Oil portion of distillate (vol. meas.) (expressed as a percentage of the emulsion) shall not exceed (3)	4.0		4.0	7		7		25
Settlement, 5 days, not more than (%) (4)	5	5	5	5		5		5
Demulsibility (%)								
35 ml. $CaCl_2$, 0.02N	30+							
50 ml. $CaCl_2$, 0.10N		75+	75+					
Stone coating, shall pass		(5)	(5)	(6)		(6)		
Tests on residue distilled to 260°C. (500°F.)								
Float test at 122°F.								200—
Float test at 140°F.		1200+	1200+	1200+		1200+		
Penetration at 25°C. (77°F.)	100–200	50–100	100–250	200+				
Solubility in organic solvents (8)								
Natural asphalt (%)		95+	95+					
Oil asphalt (%)	97.5+	97.5+	97.5+	97.5+		97.5+		97.5+
Ductility at 77°F. (cm.) (8)	40+	40+	40+					

Notes: (1) Pumpable. (2) Sprayable. (3) The oil distillate shall conform with ASTM D 396, Table 1, Grade 1. (4) This requirement is waived if the emulsion is used within 5 days. (5) See 902.09, 21b(1). (6) See 902.09, 21b(2). (7) AE-T shall consist of 80% approved AE-60 or AE-90 and 20% water containing not more than 8 grains of hardness per gallon. A Certificate of Compliance will be required. (8) The test may be waived by the Engineer. (9) AE-150-L used for light applications such as required for sand seal coats shall meet the requirements of AE-150 except the viscosity at 77°F. shall be 15 to 100 seconds and the per cent of distillate shall be 40—.

Patching C.R.C. Pavement*

In general, the minimum length of a concrete patch should be 7 feet, and the minimum width shall be the width of the lane, normally 12 feet. Attention should be given to assure that all unsound concrete is removed.

If length of patch is less than 7 feet and/or the width less than 12 feet, the following procedure shall be followed:

(a) Remove all concrete within the patch without disturbing the reinforcing steel. Replace the cement concrete taking extra care so as not to displace reinforcing steel.

Concrete Patching

The concrete used in the patch shall be high early strength or chemical admixtures for accelerating the setting of early strength concrete as stated in Section 911.03(b) may be used if approved. Place concrete in the patch area, and consolidate so as to avoid any honeycomb. The close spacing of the steel will require extra care in the placement of the concrete.

Full Depth Bituminous Patching With No. 5 Base

Bituminous patches, where specified, shall be constructed as follows:

(a) Remove all concrete and reinforcing steel and enough subbase to provide for a minimum of 12" depth. Then fill the patch with bituminous mixture for patching in accordance with Section 305.06(b) of the 1974 Indiana State Highway Specifications.

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*Special provisions.

305.06(b) If the mixture is not specified, the material shall be as set out in 403 for hot asphalt concrete base.

See section on Base Courses in this Appendix for specifications of No. 5 base.

Number 7, Number 11, or Number 12 Aggregate in French Drains*

Shoulder drains shall be constructed at each patch in accordance with Section 608 of the Standard Indiana State Highway Commission Specifications dated 1974.**

608.02 Materials. Materials shall meet the requirements specified in the following subsection of Section 900.

Course Aggregates, Class A or B....903.02

See section on Course Aggregates in this Appendix for specifications of No. 7 aggregate.

Base Courses

403.04

Type of Mixture	Coarse Aggregate Size	Fine Aggregate Size	Per Cent Passing Sieve #6	Per Cent Passing Sieve #200	Per Cent of Bitumen
Base	#4	14-2, 17	28±2	0-2	4.0-5.1
	#5	14-2, 17	25±2	0-2	4.0-5.1
	#53B	------	-----	0-5	3.3-4.4
	#73B	------	-----	0-5	3.3-4.4
Binder	#8	14-2, 17	32±2	0-2	4.0-5.1
	#9	14-2, 17	32±2	0-2	4.3-5.4
	#11	14-2, 17	37±2	0-3	4.6-6.0

*Any of these aggregates could be used.

**Special provisions.

1. Composition Limits for Base Mixtures.

Sieve Size	Total Per Cent of Aggregates Passing Sieves, Based on Total Weight of Aggregates — Coarse Aggregate Size: No. 4	No. 5	No. 53B	No. 73B
1½ inch	100	100	100	------
1 inch	76–94	87–99	80–100	100
¾ inch	56–78	67–90	70–90	90–100
½ inch	28–55	42–73	55–80	60–90
⅜ inch	21–45	26–56	-----	------
No. 4	20–39	17–39	35–60	35–60
No. 8	15–35	13–36	25–50	------
No. 16	10–30	9–28	-----	------
No. 30	4–20	3–18	12–30	12–30
No. 50	1–13	1–12	-----	------
No. 100	0–6	0–5	-----	------
No. 200	0–3	0–3	0–5	0–5

Note: For No. 4 and No. 5 base mixtures, the fine aggregate may be either size 14-2 or 17.

2. Composition Limits for Binder Mixtures.

Sieve Size	Total Per Cent of Aggregates Passing Sieves, Based on Total Weight of Aggregates — Coarse Aggregate Size: No. 8	No. 9	No. 11
1 inch	100	-----	-----
¾ inch	88–100	100	-----
½ inch	43–73	73–91	100
⅜ inch	31–55	40–73	82–98
No. 4	24–42	24–46	32–56
No. 8	18–39	18–39	22–47
No. 16	12–34	12–34	15–38
No. 30	5–22	5–22	6–25
No. 50	1–14	1–14	1–16
No. 100	0–6	0–6	0–7
No. 200	0–4	0–4	0–4

Note: The fine aggregate may be either size 14-2 or 17.

Course Aggregates for Drains and Bases

903.02 Coarse Aggregates.

(a) General Requirements. Coarse aggregates shall consist of clean, tough, durable fragments of crushed limestone or dolomite; crushed or uncrushed gravel; or crushed and processed air-cooled blast-furnace slag which is reasonably uniform in unit weight. These materials shall be free from an excess of flat, elongated, thinly laminated, soft, or disintegrated pieces and free from fragments coated with dirt or other objectionable matter. Slag coarse aggregate shall be free of objectionable amounts of iron. These materials shall comply with the following tabulated requirements.

Classes	A	B	C
[1]Per Cent of wear (by weight), Los Angeles, nor more than....	40.0	45.0	50.0
[2]Deleterious materials (per cent by weight), nor more than			
Friable particles............	0.2	0.2	----
Ocher........................	1.0	1.0	----
Shells.......................	0.7	1.0	----
[3]Soft or nondurable particles..	4.0	4.0	----
Sum of all the above, not more than..................	5.0	6.0	10.0
Chert (less than 2.45 bulk specific gravity)..........	See Notes 4 and 5		
[6]Soundness (sodium sulphate), per cent loss, not more than......	12.0	16.0	20.0
Weight per cubic foot of slag, not less than			
Sizes No. 1, No. 2...........	70.0	65.0	65.0
Other sizes..................	75.0	70.0	70.0

Notes: [1]Los Angeles abrasion requirements shall not apply to crushed blast-furnace slag.

[2]Coarse aggregates shall be free from any adherent surface coating. Aggregates that do not comply with this requirement will be rejected.

[3]Particles which are structurally weak, such as soft sandstone, shale, limonite concretions, coal, weathered schist, or cemented gravel. Requirements shall be as set out in AASHO T 189 except calculations will be made on the basis of the weight of soft particles retained on the 3/8-inch screen divided by the total weight of material retained on the 3/8-inch screen. The sum of all the above soft and nondurable particles shall not exceed 4.0%.

[4]The bulk specific gravity shall be determined in the saturated surface-dry condition.

[5]The limitations of chert (less than 2.45 bulk specific gravity) shall be as follows:

For Use In	Maximum Per Cent Allowable
Base Courses	
Aggregate	8.0
Bituminous	6.0
Cement Concrete	6.0
Surface and Binder Courses	
Bituminous	3.0
Cement Concrete (surface courses only)	3.0
Cement Concrete, General	
Foundations, Footings, and Foundation Seals	6.0
All Exposed Concrete	3.0
Culverts	3.0

The amount of chert (less than 2.45 bulk specific gravity) shall be determined on the basis of material retained on the 3/8-inch sieve for sizes No. 1 through No. 8 inclusive, No. 53, 53B, 73 and 73B. It shall be based on the No. 4 sieve for sizes No. 9 and 11. The percent of chert shall be the total weight of chert retained on the sieve specified above divided by the total weight of material retained on that sieve multiplied by 100.

[6]Aggregates failing this may be approved if (when subjected to 50 cycles of freezing and thawing) they do not have a loss greater than specified.

The absorption shall not exceed 3.0% for stone or gravel coarse aggregates used in Portland cement and bituminous mixtures.

If tests indicate characteristics in excess of the limits set out above, the aggregates may be used if aggregates from the same source have had a satisfactory service record under similar conditions of service, use, performance, and exposure. In addition, if exposed in its undisturbed position, it shall have demonstrated the ability, as shown by visual inspection, to withstand weathering after long exposure to the elements. In no case shall aggregates from a source or portion thereof be used if aggregates from that same source or portion have given unsatisfactory service and performance in previous Indiana State Highway constructions of a similar nature.

(e) Sizes of Coarse Aggregates.

	Total Percent Sieves Having Square Openings												
	4"	3½"	2½"	2"	1½"	1"	¾"	½"	⅜"	No. 4	No. 8	No. 30	No. 100	No. 200[6]
1	100	90–100	25–60		0–15		0–5							0–1
2			100	95–100		0–20	0–5	0–2						0–1[2]
4					100	70–90	45–65	10–30	0–15	0–5				0–2
5					100	85–98	60–85	30–60	10–35	0–10	0–5			0–1[1&2]
7						100	65–85	25–60		0–15	0–10	0–5		0–3
8						100	85–100	25–55	8–25	0–5				0–1[1&2]
9							100	65–85	20–55	0–10				0–2
10								100	90–100				10–30	
11								100	75–95	5–20	0–5			0–2
12								100		50–80	0–35	0–4		0–2
13										100	0–20	0–4		0–2
33			100	85–100		55–75		35–55		25–40	15–30	5–20		0–2
53[3]					100	80–100	70–90	55–80		35–60	25–50	12–30		5–10
53B					100	80–100	70–90	55–80		35–60	25–50	12–30		0–5
73[3]						100	90–100	60–90		35–60		12–30		5–10
73B						100	90–100	60–90		35–60		12–30		0–5

Notes:

1. When used in Portland cement concrete, the total per cent passing the No. 200 sieve may be 0 to 1.5 if it is dust of fracture essentially free from clay or shale.

2. When used in bituminous mixtures, total per cent passing the No. 200 sieve shall be 0 to 2.

3. The fraction passing the No. 200 sieve shall not exceed 2/3 the fraction passing the No. 30 sieve. The liquid limit of the fraction passing the No. 40 sieve shall not exceed 25 except if slag is used it shall not exceed 35 and the plasticity index shall not exceed 5. The liquid limit shall be determined as set out in AASHO T 89 and the plasticity index as set out in AASHO T 90. Unless otherwise specified, when these materials are not to be surfaced or sealed under the contract, the amount passing the No. 200 sieve shall be 5% to 12% and the plasticity index shall not exceed 7.

4. For all sizes from No. 1 through No. 33, inclusive, the amount passing the No. 200 sieve shall be determined by AASHO T 11 (decantation) only.

The gradations shown in the previous table represent the extreme limits which shall determine suitability for use from all sources of supply. The gradation of any material shall be uniform within the limits shown and shall not vary from the low limit on one sieve size to the high limit on the adjacent sieve size, nor from the high limit on one sieve size to the low limit on the adjacent sieve size. Aggregates shall be mixed uniformly and well graded between the limits specified.

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